FabTime Newsletter Abstracts

Author's Note: These abstracts were originally maintained on the FabTime website and have been copied into a single document for ease of reference.

The Waddington Effect on Wafer Fabs (Issue 25.06)

Welcome to Volume 25, Number 6 of the FabTime Cycle Time Management Newsletter. In this issue we have an exciting announcement about AskJen™, a new AI-powered expert chat feature for the FabTime software that is based on the content from this newsletter. Thank you to everyone who has been reading this newsletter over the years, asking questions, and incentivizing us to keep providing content. We are excited that the INFICON Data Science team has found a way to make this archive of content useful going forward.

We also have announcements about a repeat session of our webinar on equipment downtime and plans for the newsletter distribution going forward. Our software tip is about decluttering home page tabs. We also respond to a subscriber question about quantifying the benefits of cycle time reduction.

In our main article, we introduce The Waddington Effect, a condition in which doing scheduled maintenance can sometimes cause a short-term increase in unscheduled downtime. We discuss whether the Waddington Effect contradicts our advice to separate maintenance events rather than grouping them, as well as how to generate and use Waddington Effect Plots. We hope you find this effect as fascinating as we do.

A New Metric for the Functional Utilization that Drives Cycle Time (Issue 25.05)

Welcome to Volume 25, Number 5 of the FabTime Cycle Time Management Newsletter. In this issue we have announcements about two upcoming webinars, a new team member, and various upcoming in-person events. Jennifer also shares highlights from her LinkedIn page, as usual. This month's FabTime software tip of the month is about understanding the slice (pareto) and cross (stack) options on FabTime charts. In the subscriber discussion forum, we link to a paper related to last month's main topic, impact of downtime variability, and share a question about generating the operating curve for a fab.

Our main article this month is about a new metric called (provisionally) **functional utilization**. This metric attempts to capture the portion of utilization that drives cycle time at the tool level by distinguishing between standby time with WIP waiting and standby time when no WIP is waiting.

Improve Fab Cycle Time by Tracking the Right Equipment Reliability Metrics (Issue 25.04)

Welcome to Volume 25, Number 4 of the FabTime Cycle Time Management Newsletter. It was great seeing some of you at SEMICON West last week! Thanks to everyone who stopped by the INFICON booth. In this issue, we have announcements about a new SEMI Women in FOA forum, a webinar that I presented via the FOA about cycle time, and, most importantly, our upcoming in-person User Group Meeting. If you are a FabTime®, FPS, and/or FabGuard® customer, I urge you to

pre-register now! We also have a heads-up that the archive of past newsletter issues on the old FabTime website will only be available for a short time. If you would like access to those issues, download them soon!

Our software tip of the month is about generating scrap charts in FabTime. We also have a subscriber discussion about using OEE in factories (front and back end) and another about metric trees for fabs. Our main article is about the impact of downtime on the fundamental drivers of cycle time and what that implies for metrics selection. Tracking the right equipment reliability metrics and using them as a basis for communication between fabs and equipment suppliers is a way to drive cycle time improvement.

What Makes an Effective Daily Fab Status Meeting? (Issue 25.03)

Welcome to Volume 25, Number 3 of the FabTime Cycle Time Management Newsletter. In this issue we have announcements about an FOA Webinar that Jennifer will be presenting on cycle time and about the FabTime team's first INFICON in-person User Group Meeting. There's also a head's up about an upcoming need to re-subscribe the newsletter, together with our usual highlights from industry news on LinkedIn. Our software tip of the month is about using FabTime to drill down into root causes, with a detailed example from our demo server.

There's a plethora of subscriber discussion in this issue, about standby-WIP-waiting time, value stream mapping (which two different people brought up), software for predicting outs, WIP Turns rates, and test wafer ratios. In our main article, we revisit the topic of what makes an effective daily fab status meeting, ranging from general thoughts on meeting purpose and structure to specific ideas about content that should be included.

On the Benefits of Cycle Time Education (Issue 25.02)

Welcome to Volume 25, Number 2 of the FabTime Cycle Time Management Newsletter. This is the first full newsletter issue since FabTime was acquired by INFICON (though I did send a Cycle Time Tip e-mail last month). Thanks for being here with us on this new stage in the FabTime journey. I'm happy to report that the FabTime team is doing well and has been made welcome by the team at INFICON.

This issue also includes an announcement about the upcoming Advanced Semiconductor Manufacturing Conference, as well as the usual highlights from my LinkedIn. Our software tip of the month is about creating a question for display in the FabTime charts menu from a chart. This month's subscriber discussion forum has feedback from subscribers about box plots, standby-WIP-waiting time and test wafer ratios, as well as a question from me about cycle time challenges in assembly and test factories. I'm looking for input in the hope of writing about back-end factories in a future issue.

In our main article this month, we discuss the benefits of educating people on your team about the fundamentals of cycle time management. We share some history about how our cycle time class came to be, as well as an overview of the topics that we have chosen to include, and why. We close with some of our favorite things to teach, and a few success stories. We welcome your feedback.

New Metric: Cycle Time Impact of Hot Lots (Issue 25.01)

Welcome to Volume 25, Number 1 of the FabTime Cycle Time Management Newsletter. We hope that your 2024 is off to a great start! In this issue, we have an announcement about the release of the new version of FabTime's software to early adopter sites, as well as the usual highlights from Jennifer's LinkedIn (Lots of wafer fab-related news has been circulating over the past couple of months). Our software tip of the month is about using the new version of FabTime to generate box plots (a long-time goal of Frank's). In our subscriber discussion forum, we have detailed responses to last month's main article about cycle time improvement for 300mm fabs and to a recent subscriber question about managing cycle time for external processes. We so appreciate these subscribers for taking time out of their busy schedules to contribute.

In the previous subscriber discussion forum, we introduced a new metric, requested by a prospective customer, for quantifying the impact of hot lots on regular lot cycle time. After we discussed this metric with our user group, it became clear that a more detailed explanation was needed. In our main article this month we have started with the example from the previous issue and expanded it into a more comprehensive discussion. We think this metric is important because it offers a way to show management the cost of ever-increasing quantities of hot lots in the fab.

Cycle Time Improvement for 300mm Fabs (Issue 24.05)

Welcome to Volume 24, Number 5 of the FabTime Cycle Time Management Newsletter. In this issue, we have a quick recap of the recent Fab Owners Alliance meeting, an announcement about FabTime's new chart engine, and a variety of articles from Jennifer's LinkedIn. Our software tip of the month is about using our Process Time Lot List and Tool State Gantt charts to analyze lot cascading, with the goal of driving improvements in tool utilization.

In our subscriber discussion forum, we share poll results on a question about top contributors to fab variability. We also share a subscriber question about managing the cycle time of external processes and a response to our recent software tip of the month about using smaller carts. We also share an example of a chart requested by a prospective customer for assessing the cycle time impact of hot lots.

In our relatively brief main article, we respond to a question from a subscriber who asked which of our recommendations are more applicable to 300mm fabs vs. less automated 200mm and smaller factories. We categorize some operational differences between these factories and share a few recommendations for 300mm (and highly automated 200mm) fabs.

Commonly Reported Wafer Fab Cycle Time Contributors (Issue 24.04)

Welcome to Volume 24, Number 4 of the FabTime Cycle Time Management Newsletter. In this issue, we have a SEMICON West wrap-up and announcement about the upcoming Fab Owners Alliance meeting, a call for papers for the 2024 Advanced Semiconductor Manufacturing Conference, and various news links from Jennifer's LinkedIn. Our software tip of the month is about using sparklines (very small, data-dense charts) to convey large amounts of information in a single dashboard. We have a plethora of subscriber discussion topics ranging from a timely question about AI/ML to tool queue times and control plans to a response to the prior issue about forward-looking cycle time metrics.

Because of the large quantity of subscriber topics, we have included a relatively short main article. Over the years, we have surveyed people on our website and in our cycle time management course, and more recently via LinkedIn, about what they see as the primary drivers of cycle time for their fabs. We share highlights from these responses, with some thoughts from Jennifer on why the complexity of fabs makes them so interesting.

Forward-Looking Cycle Time Metrics (Issue 24.03)

Welcome to Volume 24, Number 3 of the FabTime Cycle Time Management Newsletter. It's been an exciting time for FabTime of late. In this issue we have announcements about two new FabTime employees, a new video and page for requesting software demos, and our first-ever booth at SEMICON West. We also have a plethora of subscriber discussion, ranging from responses to last month's cycle time tip about reducing the number of hot lots to selecting fab dispatch rules and making plans for particle checks on multi-chamber tools.

In our software tip of the month, we show how to vary the x-factor on a projected lot completion chart to do what-if analysis on the lot's future cycle time. This tip ties in to our main article, which is about forward-looking cycle time metrics for wafer fabs, something a number of our customers and subscribers have been interested in recently. We discuss the use of planned cycle times to forecast completion dates for individual lots, and then review three different metrics that each predict future average cycle times based on current fab performance: dynamic x-factor, summed operation cycle time, and turns-predicted cycle time (a new metric based on WIP turns). As always, we welcome your feedback.

Managing Time Constraints between Process Steps in Wafer Fabs (Issue 24.02)

Welcome to Volume 24, Number 2 of the FabTime Cycle Time Management Newsletter. In this issue, we have an exciting staffing update about the promotion of Lara Nichols to become FabTime's President. We also have an announcement about our recent collaborative case study with Flexciton at the Fab Owners Alliance meeting, as well as the usual updates from Jennifer's LinkedIn. Our software tip of the month includes two ways of measuring the duration of downtime events, following up on a tip from the last issue.

We have a plethora of subscriber discussion in this issue, including calculating theoretical cycle time, X-Factor, and the value of a day's worth of cycle time, as well as managing bottlenecks. Our final subscriber question, about managing a process sequence with time constraints between steps inspired us to make time constrained processing the topic of this issue's main article. Jennifer studied time constrained systems for her PhD research and has been remiss in not delving into this complex topic sooner. She discusses capacity planning methods for time constrained systems, then moves on to operational issues, and closes with a few recommendations for coping with time constraints in practice. As always, we welcome your feedback.

10 More Recommendations for Improving Fab Cycle Time (Issue 24.01)

Welcome to Volume 24, Number 1 of the FabTime Cycle Time Management Newsletter. In this issue, we have an announcement about a case study that we'll be presenting at the Fab Owners

Alliance next week, an update about our efforts to change the platform that we use to send the newsletter, and an announcement about new training and informational materials for software customers. Our software tip of the month is about using the newly modified Dynamic X-Factor chart in FabTime. We have subscriber discussion about the best way to share alerts, how to identify bottlenecks in the fab, and whether to set a lower bound on the number of hot lots.

Our main article this month was inspired by the positive response that we've received to our new cycle time improvement tip emails. We shared a list of ten recommendations for improving fab cycle time two years ago, and today we introduce ten additional recommendations. While not all these recommendations will be relevant for all readers, we hope that each of you finds something useful in the discussion. If you have additional tips for improving fab cycle time, we would love to compile and share those in the future.

A Fab Cycle Time Improvement Framework (Issue 23.06)

Welcome to Volume 23, Number 6 of the FabTime Cycle Time Management Newsletter. In this issue, we have an important announcement about a new platform (MailChimp) that we'll be using to send the newsletter and tip emails starting in January. You may need to mark the messages as safe to avoid them being junked by your email program (and we would of course appreciate that very much!). We also have an announcement about the newest version release of FabTime's software, and a few news stories shared from Jennifer's LinkedIn.

Our software tip of the month is about restricting the number of points displayed on a Pareto chart. Our subscriber discussion topics include green-to-green chart implementation, controlling variation in lot arrivals across factories, and (per last month's tip), separating maintenance events. A subscriber question about ranking of cycle time improvement tactics inspired us to share a proposed fab cycle time improvement framework as this month's main article. In this piece, we suggest what we think is a logical order for identifying cycle time improvement targets and then applying different strategies. We also include a list of the fab complexities that contribute to cycle time. We welcome your feedback, as always.

Managing One-of-a-Kind Tools (Issue 23.05)

Welcome to Volume 23, Number 5 of the FabTime Cycle Time Management Newsletter. In this issue we have a call for papers for the upcoming Advanced Semiconductor Manufacturing Conference and a quick note about the upcoming Fab Owners Alliance meeting. Jennifer hopes to see some of you there! We also have, as usual, a few articles from Jennifer's LinkedIn. Our software tip of the month is about using our Ag-Grid charting engine to generate different types of charts on your own. Customers who have asked over the years for pie charts – this tip is for you.

In our subscriber discussion forum, we have a response to the previous issue's main article on holds. We also have two responses to our new cycle time improvement tip of the month feature, which we kicked off by talking about finding and eliminating process restrictions. We also have a new question about managing a fab with many one-of-a-kind tools. This question made us realize that although we often speak of why it's good NOT to have one-of-a-kind tools, some of our readers don't have that luxury. In our main article, we share recommendations for coping with one-of-a-kind tools. As always, we welcome your feedback.

Cycle Time and Holds Revisited (Issue 23.04)

Welcome to Volume 23, Number 4 of the FabTime Cycle Time Management Newsletter. It's been a busy summer both within FabTime and around the industry. We are pleased to announce three new FabTime employees (one already with us and the other two starting soon). We also share several industry news tidbits from Jennifer's LinkedIn, including the fact that wafer fab investments are headed to a record high this year. As suppliers to wafer fabs, we are grateful to see this capital expenditure. As long-time observers of the industry, we remain a bit nervous about potential capacity over-expansion. But we are overall hopeful!

We have no subscriber discussion in this issue. Perhaps all our readers were on vacation when the last issue came out.

In our main article this month we return to a topic last addressed here more than 15 years ago: the cycle time impact of holds. We discuss several ways that holds increase cycle time and share some associated management challenges arising from holds. We close with several recommendations for minimizing the impact of holds. In this month's software tip, we focus on how to remove holds from the list of inactive lots, while keeping them visible using other charts. As always, we welcome your feedback.

Delivery Performance in Overloaded Wafer Fabs (Issue 23.03)

Welcome to Volume 23, Number 3 of the FabTime Cycle Time Management Newsletter. In this issue we have an announcement about a workshop we are holding for our software customers, as well as several articles from Jennifer's LinkedIn about the chip shortage and the high-tech labor shortage. Our FabTime tip of the month is about using fiscal calendars when configuring FabTime charts.

Our subscriber discussion forum is brimming with questions and responses on topics from queue time limits to WIP linearity to capacity planning to operator productivity. We also have a response to the previous issue on managing cycle time while ramping starts. Our main article this month was inspired by a discussion with Hani Ofeck about meeting delivery performance targets in overloaded fabs. We welcome your feedback on that, as well as on the other subscriber discussion topics.

Managing Fab Cycle Time while Ramping Starts (Issue 23.02)

Welcome to Volume 23, Number 2 of the FabTime Cycle Time Management Newsletter. In this relatively brief issue, we have some highlights from Jennifer's LinkedIn posts, a FabTime software tip of the month about using our new on-chart drill-down capability, and subscriber discussion about defining the components of cycle time and measuring fab linearity.

Our main article this month was inspired by a new subscriber to the newsletter. We always ask people who fill out subscription requests on our website "What is the most urgent cycle time issue occurring in your fab?" This subscriber wrote: "Ramping up starts and maintaining cycle time." We realized that although we've written in the past about what to do to during an industry downturn, we had never written an article about what to do to protect cycle time during a strong upturn. We

decided to remedy that omission. We share tips for squeezing additional capacity out of an existing tool set, deciding where to add capacity, and spending money in other areas beyond tools, all with an eye to keeping cycle times under control. We welcome your feedback, as always.

Using Operating Curves in Real Fabs (Issue 23.01)

Welcome to Volume 23, Number 1 of the FabTime Cycle Time Management Newsletter. We hope that the new year is treating you all well. In this issue we have a question assessing potential interest in a multi-company session of our cycle time management course, an announcement about the FOA Collaborative Forum (in person as of this writing), and some highlights from Jennifer's LinkedIn. We have a FabTime software tip about the use of our new search bar. We have subscriber discussion about various topics, including a recommendation for a new blog on Factory Physics that we believe subscribers to this newsletter will enjoy.

We've talked many times in this newsletter about using queueing model-based operating curves to illustrate the impact of various factors on wafer fab cycle time. In our main article this month, we discuss the idea of populating these operating curves with data from real fabs. Reasons to do this include estimating the impact on cycle time from changes in utilization or other parameters and identifying places in the fab where the cycle time is worse than might be expected given the known characteristics of a tool group. We discuss techniques and pitfalls of collecting data for this effort. We show a detailed example from our demonstration server and then highlight possible uses of the operating curves. As always, we welcome your feedback.

Managing Operators During a Staffing Shortage (Issue 22.05)

Welcome to Volume 22, Number 5 of the FabTime Cycle Time Management Newsletter. We hope this issue finds you all well. In our community news section, we share links to several articles about the current chip shortage and resulting capacity expansion plans. In our subscriber discussion forum, we share some additional resources related to a topic raised in the previous issue: critical ratio values by zone.

In our software tip and our main article this month we address the topic of managing operators during a staffing shortage. We chose this topic after hearing from various fabs that the current economic environment has led to difficulties in finding sufficient operators. In the main article, we identify four fab management issues that may be exacerbated by a lack of operators and discuss ways to mitigate the impact of operator unavailability on cycle time.

Fundamental Drivers of Wafer Fab Cycle Time (Issue 22.04)

Welcome to Volume 22, Number 4 of the FabTime Cycle Time Management Newsletter. In this issue we have an announcement about a promotion for Jean Paul Tu, now Principal Engineer for FabTime and another about the Fab Owners Alliance. We also share a few recent news stories from Jennifer's LinkedIn feed. Our FabTime software tip of the month is about customizing data tables using our relatively new data table engine, Ag-grid. We also introduce a new subscriber discussion topic about the application of critical ratio dispatching to wafer fabs.

In response to the continuing chip shortage, we've seen interest in understanding and improving fab performance from many quarters. In our main article we return to basics, discussing the three

fundamental drivers of wafer fab cycle time, with added detail from our cycle time management course. We hope you'll consider sharing this article with others.

Quantifying the Impact of Rework on Fab Cycle Time (Issue 22.03)

Welcome to Volume 22, Number 3 of the FabTime Cycle Time Management Newsletter. We hope you're enjoying summer wherever you are and are finding the chip shortage positive for your business' bottom line. In this issue we have announcements about some FabTime staffing changes and delivery of our cycle time management course, as well as some highlights from industry news that Jennifer has been sharing on LinkedIn. We also have subscriber discussion about lot splitting for 300mm fabs and managing during a supply crunch.

In our main article, we discuss the impact of rework on fab cycle time, a topic that we have not previously addressed in the newsletter. We share a companion software tip on how to estimate the percentage of rework in FabTime.

10 Recommendations for Fab Cycle Time Improvement (Issue 22.02)

Welcome to Volume 22, Number 2 of the FabTime Cycle Time Management Newsletter. In this issue we have a few links from Jennifer's LinkedIn, but no other announcements. Our software tip of the month is about using FabTime to identify possible instances of soft dedication in the fab. We have subscriber discussion about WIP Utilization %, sending SMS email to Japanese cell phones, breaking up maintenance events, managing SPC in a shared fab environment, and paying off technical debt.

Our main article was inspired by the many reports we've seen and heard lately of fabs facing capacity and cycle time challenges. We've spent 20+ years thinking and teaching about ways to improve cycle time for existing fabs. We've always closed our cycle time course with a list of our top ten recommendations. Most of these have been covered in past newsletters, but we thought there would be value in a single article that describes all ten. We hope you find these recommendations useful.

On Breaking Up PMs and Other Unavailable Periods (Issue 22.01)

Welcome to Volume 22, Number 1 of the FabTime Cycle Time Management Newsletter. This is the first issue of 2021. 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.

Little's Law and Metrics Selection (Issue 21.06)

Welcome to Volume 21, Number 6 of the FabTime Cycle Time Management Newsletter. In this issue, we have a couple of FabTime-related announcements, a quick recap of the recent Fab Owners Alliance virtual meeting, and a few links of potential interest to the newsletter audience. Our software user tip of the month is about using the SQL filter on FabTime charts. This allows end users to perform specialized filtering without needing help from IT (or from FabTime). In our subscriber discussion forum, we share a question from a long-time subscriber about process step numbering.

Our main article this month is about Little's Law, a fundamental relationship that drives factory behavior. In addition to providing an intuitive derivation of Little's Law, we discuss the implications of Little's Law on metrics selection for wafer fabs.

Further Thoughts on Short-Term Bottlenecks (Issue 21.05)

Welcome to Volume 21, Number 5 of the FabTime Cycle Time Management Newsletter. We come to you this month from a smoky California, where FabTime's team is safe, well, and grateful for firefighters. We have no community announcements in this issue, but we do have a few industry news tidbits from Jennifer's LinkedIn feed. Our software tip of the month is about using the forecast arrivals charts in FabTime.

We received several detailed responses to last month's article about identifying short-term bottlenecks, including one that questioned the merits of looking at short-term bottlenecks in the first place. In our main article this month, we aggregate and respond to those contributions. We discuss potential extensions to the WIP Hours paradigm, additional methods for identifying short-term bottlenecks, and uses of short-term bottlenecks as indicator species to tease out underlying variability problems in the fab.

Identifying Short-Term Bottlenecks (Issue 21.04)

Welcome to Volume 21, Number 4 of the FabTime Cycle Time Management Newsletter. We hope this issue finds you and your family all safe and well and managing in this COVID-changed time. In this issue we have an announcement about our upcoming software release and a few tidbits of potential interest to the newsletter community. In our subscriber discussion forum, we have a request for information sharing related to the state of the art in planning, scheduling, and dispatch, and another regarding the potential elimination of lead wafers in photo. We also have a suggestion regarding the column format for the PDF newsletter. You'll see in today's issue, for PDF subscribers, that we're experimenting with a single-column format for improved mobile-friendliness.

Foreshadowing our main article, this issue's software tip of the month is about using tab filters to track short-term bottlenecks. The main article was written in response to a subscriber question about how to identify those tools likely to be a problem over the coming shift or day. We define short-term bottlenecks and discuss using the new WIP Hours metric to identify them. Following a detailed example illustrating the use of WIP Hours and tool status information, we close with a discussion of other metrics likely to tease out short-term bottlenecks from the vast array of fab metrics. We hope you find this useful and welcome discussion of other approaches for tracking short-term bottlenecks.

COVID-19 Impacts for Wafer Fabs and Cycle Time (Issue 21.03)

Welcome to Volume 21, Number 3 of the FabTime Cycle Time Management Newsletter. We hope that this issue finds you and your families safe and well and your communities returning to a life that's a bit closer to pre-pandemic normalcy.

In this issue, we have announcements about past FabTime newsletters, new Winter Simulation Conference papers, and SEMI resources - plenty of reading material for anyone who needs it. Our software tip of the month is about using FabTime to share data with team members from whom you are physically separated. In our subscriber discussion forum, we have an update to last month's topic of Demand OEE, a question about Factory Physics-type courses, and a question from us about our cycle time course.

In our main article, we discuss impacts of COVID-19 on wafer fabs. We highlight several changes that we have learned about from our reading and from discussions with our User Group. We also discuss ways that some of these changes may be impacting fab cycle times. As always, we welcome your feedback.

Demonstrations of Flexible Thinking during a Global Crisis (Issue 21.02)

Welcome to Volume 21, Number 2 of the FabTime Cycle Time Management Newsletter. It's a changed world since we sent out the last issue in early February. Today, as we prepare to send this issue, the coronavirus is threatening millions of people across countries worldwide. Many people are hunkered down and working from home. Even when people are working in the office, companies are reducing the number of meetings and people are maintaining as much physical distance as they can.

This is all for a greater goal, of course, but it's also important that we as an industry continue learning from and connecting with one another. We hope that in a small way this newsletter can help with that. In this issue we share community announcements (some regarding COVID-19 resources) as well as tips for using FabTime's software remotely. We also have subscriber contributions and questions from colleagues around the world. Please consider responding. We are stronger together.

In our main article, we highlight examples from recent news stories that illustrate flexible thinking by companies and government agencies as they respond to COVID-19 shortages and shutdowns. As a company focused on performance improvement, we find these examples encouraging.

Finding and Analyzing Cycle Time Bottlenecks (Issue 21.01)

Welcome to Volume 21, Number 1 of the FabTime Cycle Time Management Newsletter. We hope that you are all off to a great 2020 and believe that it is going to be a great year for the semiconductor industry. Would you believe this is the 159th issue of the newsletter? In this issue we have an exciting announcement about a plan to make past newsletter issues available to subscribers. Our software tip of the month is about a starter set of charts for manufacturing supervisors. We have subscriber discussion about dispatch compliance, on-time delivery calculations, rework %, and queue time sub-states.

Inspired in part by the discussion on queue time sub-states, we focus our main article on cycle time bottlenecks: the tool groups that contribute the most queue time to cycle time in a fab. We describe methods for both identifying cycle time bottlenecks and analyzing them. We close with a brief summary of concrete recommendations for mitigating the primary contributing factors to cycle time bottlenecks. We welcome your feedback.

Dispatch Compliance in Wafer Fabs (Issue 20.06)

Welcome to Volume 20, Number 6 of the FabTime Cycle Time Management Newsletter. We hope that the holiday season is treating you all well. A special welcome to our many new subscribers this month. The October issue was well-received, and we thank everyone who passed it along to their colleagues.

In this issue, we start with one announcement about an upcoming new software release and another highlighting some recent news shared by Jennifer on LinkedIn. Our FabTime user tip of the month is, following up with the previous issue, about how to generate a list of current tool qualification bottlenecks (operations that have WIP and only a small number of qualified tools).

We have a robust subscriber discussion forum this month, with a small correction to the previous issue and a new topic for which we are seeking input: breaking down queue time into sub-states based on operator unavailability, downtime, and lack of tool qualification. We also have several responses to a question we posed last month about dispatch compliance, leading into our new main article on that topic. Aggregating inputs from the literature, the subscriber community, and FabTime's customers, we identify three primary approaches to tracking and reporting dispatch compliance. As always, we welcome your feedback.

The Impact of Tool Qualification on Cycle Time (Issue 20.05)

Welcome to Volume 20, Number 5 of the FabTime Cycle Time Management Newsletter. In this issue we have an announcement about the upcoming meeting of the Fab Owners Alliance and another about connecting with FabTime on LinkedIn. Our FabTime software tip of the month is about how FabTime calculates standby-WIP-waiting time, and why that is useful information.

We are trying something new with the subscriber discussion forum this month. We are seeking feedback in advance of the planned main article for the next issue of the newsletter: dispatch compliance. Any responses will thus be included in the same issue, and easier to refer to in the future. We also have a question from a subscriber about cycle time benchmarking. We would welcome responses from readers on that topic also.

In our main article for this issue, we discuss the impact of tool qualification on cycle time. While the impact of one-of-a-kind tools on fab cycle time is well known, the price of tool qualifications that lead to single-path operations is more significant than is sometimes realized. We illustrate this via FabTime’s Operating Curve Spreadsheet tool, which we are making available to newsletter subscribers for the first time. We hope you find the spreadsheet, and the discussion, useful.

How the Space Program Launched the Semiconductor Industry (Issue 20.04)

Welcome to Volume 20, Number 4 of the FabTime Cycle Time Management Newsletter. We hope you're all having a great summer. We have no community announcements in this issue, but we have shared links to a couple of recent news stories that we thought would be of interest to our subscriber community. Our software tip of the month is about viewing the distribution of WIP across the line, with additional detail about the breakdown of that WIP.

We have two extensive and thoughtful subscriber responses to the main topic of the previous issue: the metric WIP Hours (hours of WIP in queue per tool). As these responses have made the subscriber discussion both lengthy and technical, we have chosen to include a brief main article. Inspired by the recent burst of news about the 50th anniversary of the moon landing, we share some commentary about the impact of the US space program on the semiconductor industry. We welcome your feedback.

Defining a Metric for WIP Hours (Issue 20.03)

Welcome to Volume 20, Number 3 of the FabTime Cycle Time Management Newsletter. In this issue we have an announcement about availability of new papers from the Winter Simulation Conference. Our software tip of the month is about saving data table configurations. We have no subscriber discussion this month, but we are seeking feedback about a metric defined in our main article: WIP hours. WIP hours is a metric used to compute the hours of WIP waiting at each tool, normalized by the number of tools that are qualified to run each wafer. We believe the WIP hours could be useful in identifying short-term bottlenecks and tool groups that could particularly benefit from additional cross-qualification. As always, we welcome your feedback.

A Metric for Green-to-Green (G2G) Analysis (Issue 20.02)

Welcome to Volume 20, Number 2 of the FabTime Cycle Time Management Newsletter. In this issue we have a call for papers for an upcoming conference. Our software tip of the month is about using our new interface for renaming, copying, and linking to home page tabs. We also have an extensive subscriber submission about capacity planning, on-time delivery, and dispatching.

In our main article, we discuss the metric Green-to-Green (G2G) time, which we are in the process of implementing in our software. This metric captures each instance of downtime, scheduled and unscheduled, from when a tool first goes down until it comes back up, even if there are multiple switches between downtime sub-states in between. We believe that this metric will be helpful to fabs in understanding and reducing downtime-related variability.

Cycle Time Metrics for Make to Stock vs. Make to Order (Issue 20.01)

Welcome to Volume 20, Number 1 of the FabTime Cycle Time Management Newsletter. It's hard to believe that this is the 20th year of publication for this newsletter. Many thanks to all who have joined us along the way. We welcome your feedback on topics that we should cover in the coming year.

We hope that everyone's 2019 is off to a great start. This issue's software tip is about enabling and using FabTime's JavaScript charting engine. In our subscriber discussion forum, we seek your input regarding a new metric that we are implementing, Green to Green time. In our main article, we discuss metrics for make to stock vs. make to order production. Specifically, we question the use of the On-Time Delivery (OTD) metric for lots that are make to stock and suggest other approaches.

Tips for Sending More Productive Emails (Issue 19.05)

Welcome to Volume 19, Number 5 of the FabTime Cycle Time Management Newsletter. We hope that those of you in the US had a relaxing Thanksgiving holiday and we wish everyone a joyful holiday season and a happy and productive 2019. March will mark the 20th anniversary of FabTime as a company, and we are grateful for all of the colleagues, customers, newsletter subscribers and friends that we've made over that time.

In this final newsletter issue of the year, we have an announcement regarding our successful OEE webinar. Our FabTime tip of the month is about using a new feature to rotate charts by 90 degrees. We have one response to our previous issue's main article about the proposed metric delta to moves goals. Our new main article contains tips for sending more productive emails, inspired by some discussion at the October Fab Owners Alliance meeting. We welcome your feedback and thank you for reading, as always.

A Possible Metric Regarding Delta to Moves Goal: Updated (Issue 19.04)

Welcome to Volume 19, Number 4 of the FabTime cycle time management newsletter. In this issue we have an announcement about a new FabTime webinar on OEE that we will be hosting in late October. (Sorry, the webinar is for software customers only.) Our FabTime software tip of the month is about identifying tools that have been defined as batch tools in FabTime and looking at their performance. In our main article, we explore possibilities for a new metric that captures variation from move goals (by fab, area, or tool group) over time. The idea behind the metric is to reduce variability by meeting moves goals more consistently from day to day.

Cycle Time and Hot Lots: Updated (Issue 19.03)

Welcome to Volume 19, Number 3 of the FabTime cycle time management newsletter. We have in our community news section an abstract from a recent conference regarding the development of a new set of semiconductor testbed datasets. Our software tip of the month is about tracking the percentage of hot lots in your fab using FabTime's Excel export functionality.

We have no subscriber discussion at this time. However, our main article was inspired by a subscriber asking if we had ever written about hot lots. We had done so, but not for more than a dozen years, and we felt that the topic was due for an update. We have extended our previous discussion about the impact of hot lots on cycle time, adding some recent research as well as new discussion regarding metrics and the impact of hot lots on fab capacity.

Using Trendlines to Improve Fab Performance (Issue 19.02)

Welcome to Volume 19, No. 2 of the FabTime Cycle Time Management Newsletter. In this issue we have community announcements including a call for papers for the e-Manufacturing & Design Collaboration Symposium and about the next Fab Owners Alliance meeting. We have no subscriber discussion at this time (though we do welcome your questions and feedback).

In our tip of the month for this issue we discuss how to add a trendline to any FabTime chart. In our main article we address the use of trendlines more generally for fab performance improvement. We include examples of charts for which trendlines might be particularly useful, and discussions about the value of linear vs. more complex trendlines for day to day performance analysis. Our thanks to members of the FabTime User Group for suggesting trendlines as a topic.

Determining Availability Targets (Issue 19.01)

Welcome to Volume 19, Number 1 of FabTime's Cycle Time Management Newsletter. We hope that everyone had a happy holiday season, and that you are all successfully fending off winter ailments. In this issue of the newsletter, we have an announcement about a FabTime webinar that was held in January (and is available for viewing by FabTime customers). We have a subscriber discussion question about hot lots. Our FabTime software tip of the month is about adding a new chart series on the right-hand Y-axis when customizing charts.

In our main article this month, written with Hani Ofeck from Tower Semiconductor, we explore the setting of availability targets. While availability is an important and widely tracked metric in fabs, there is surprisingly little literature regarding the calculation and implementation of availability targets. In our article we share some general thoughts as well as implementation ideas. It is our hope that this will spur further discussion, such that we, the FabTime newsletter community, can improve our collective understanding in this area.

Our Required Reading List for New Employees (Issue 18.06)

Welcome to the final issue of Volume 18 of the FabTime newsletter. We hope that you are all having a happy holiday season. In this issue, we are pleased to announce the launch of a new FabTime.com website. We also share a link to some SEMI webinars that we think subscribers may find useful. Our software tip of the month is about sorting stacked bar charts by height. We have two subscriber responses to the last issue, about core practices in transitioning a factory from R&D to production.

In our main article this month, we share FabTime's required reading list for new employees (mainly programmers). We explain our motivation for starting off with these titles and include brief reviews of all four. We feel that understanding the concepts in these books can make our employees more effective, and at the start of a new year, we would like to share that possibility with our subscribers.

Helping Factories Transition from R&D to Production (Issue 18.05)

In this issue we have two FabTime announcements. The first is about the release of software patch 109. The second is about our latest training webinar. Our software tip of the month is about how to open a new chart in a new tab. We have no subscriber discussion this month.

Our main article was inspired by our attempts to help a new customer as they move from a development environment to higher volume manufacturing. We mine our years of experience in working with wafer fabs to propose three core practices and six categories of key metrics for volume factories. We believe that all of these may help this new customer (and other readers, of course). As we have not personally run a wafer fab, however, our musings have raised a number of new questions. We are hoping that some of you will be inspired to share your experience in this area, which we will then disseminate in the next issue.

Measuring Variability of Availability (Issue 18.04)

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.

Understanding Why Lots Miss Their Due Dates (Issue 18.03)

In this issue we have a brief announcement about our first webinar-based training session. Our FabTime user tip of the month is about a shortcut for opening multiple home page tabs quickly. In our subscriber discussion forum we have several responses to the last newsletter topic of fab shutdowns. We think you'll find them interesting.

In our main article this month we discuss using root cause analysis to better understand lots that miss their due dates. In addition to providing a structure for such analysis, we suggest some ways for using the outcome of the analysis to catch future lots earlier, before they become late. As always, we welcome your feedback.

Variability Impact of Temporary Fab Shutdowns (Issue 18.02)

Our FabTime software tip of the month is about toggling the display of data values on bar chart series. Though we have no new subscriber discussion, we have used that section of the newsletter

to share two recent papers that we think will be of particular interest to our subscribers. The first is about sources of variability in wafer fabs. The second is about breaking up long PMs to improve cycle time.

Our main article this month is about temporary fab shutdowns. We discuss the reasons and general types of temporary shutdowns, the ways that people prepare for planned shutdowns, and recovery from shutdowns. We also discuss the impact of fab shutdowns on factory systems, particularly reporting systems. We would appreciate any feedback from newsletter subscribers who have real-world experience in managing shutdowns from the fab side.

Learning New Things and Making Them Stick (Issue 18.01)

In this issue, we are pleased to announce the imminent release of software Patch 108, containing lots of great new functionality. We also have an announcement about the upcoming Fab Owners Association Collaborative Forum. Our software user tip of the month is about generating a list of tools that have been down for more than some time period (e.g. 12 hours), using the new E10Age filter. We have no subscriber discussion in this issue, though we do welcome your questions and feedback.

In our main article this month we share highlights from Make It Stick, a book about the science behind successful learning. Because making significant improvements often involves learning new things, and because all of us face opportunities for learning and growth in our personal lives, we felt that this topic would be of interest to the newsletter community. We welcome your responses.

Thinking Critically About Data (Issue 17.06)

In this issue we have a community announcement about the 25th anniversary of Wright Williams and Kelly. Our software tip of the month is about using the relatively new stacked starts and shipments charts. We have no subscriber discussion during this busy time of year.

We have a new type of main article this month. We share a detailed recap of a new nonfiction title including our own commentary on how the topic relates to the semiconductor industry. The book highlighted is “A Field Guide to Lies” by Daniel Levitin, about applying critical thinking to information presented in the form of data, words, and pictures. We also include a recent example of a statistic miscalculated by Facebook, as well as discussion, where applicable, of how Levitin’s comments apply to FabTime and other reporting products. We would be especially interested to know whether you find this type of article useful.

Computational Issues in Reporting "Average WIP" (Issue 17.05)

In this issue we have one announcement, about FabTime team members running the SLO Ultra. Our software tip of the month is about copying chart images to other applications (a modified tip that reflects changes due to our custom JavaScript charting engine). We have a subscriber discussion question regarding the choice between one automatically loaded tool and two manually loaded tools. Long-time readers will be able to guess FabTime’s thoughts on that question.

In our main article this month we look at computational issues in reporting and calculating WIP-related metrics, particularly WIP turns. If there is one thing that we’ve learned in our years of

working with fab data, it's that even things that seem straightforward can become complex, when you get down into the nitty-gritty details. Computing average WIP is no exception. As always, we welcome your feedback.

Managing High-Mix Low-Volume Wafer Fabs (Issue 17.04)

In this issue we have a brief announcement about two new FabTime interns. Our software user tip of the month describes two ways to move a chart to a different home page tab. We have no subscriber discussion this month, but we do have a main article that we hope will generate discussion for future issues.

This main article, co-written with Mike Hillis from Cypress Semiconductor, is about the rise of and challenges in managing high-mix, low-volume fabs. The increased market segmentation of high-tech products is likely to drive ever-increasing levels of product mix, with lower volumes of many individual products. This combination of high mix and low volumes exacerbates many of the management challenges already present in wafer fabs. It is in all of our interest to come up with better solutions for managing such facilities. We hope that this article launches a productive discussion.

Why Fabs Need Multiple Metrics (Issue 17.03)

In this issue we have an announcement about the FabTime Virtual User Group. Our software tip of the month is about using effective dates to ramp goals over time. We have one subscriber discussion topic, concerning the benefits of foundries vs. in-house fab manufacturing.

In our main topic this month we discuss the pressure that arises sometimes in fabs to focus on a single metric, and the reasons that this isn't a good idea in the complex environment of a fab. We review a number of candidate super metrics and conclude with a framework for using multiple metrics in an integrated fashion. As always, we welcome your feedback.

FabTime Short-Interval Scheduling (Issue 17.02)

In this issue we have calls for papers for two upcoming conferences, both of which include topics that may be of interest to the newsletter community. Our software tip of the month is about controlling the way that slice-by objects are filled in (when they have no WIP) on WIP and Moves Pareto charts. We have no subscriber discussion this month, though we do welcome your questions or feedback on fab manufacturing-related topics.

In our main article, we introduce the methodology included in FabTime's new short-interval scheduling module. The scheduler attempts to solve certain issues inherent in traditional dispatch systems by looking forward to create a series of reservations for each tool. This better handles fab complexities like back-to-back time constraint regions and setup avoidance planning. We welcome your feedback.

A Hidden Source of Cycle Time in Wafer Fabs: Gas and Chemical Changes (Issue 17.01)

In this issue we have an announcement about a promotion for FabTime's Teresa Fallwell, and about FabTime's participation in next week's FOA Collaborative Forum. Our software tip of the

month is about sorting moves trend and pareto charts by delta from goal (to identify objects that are furthest from meeting their goals). In our subscriber discussion forum we have several responses to last issue's main article about cluster tool OEE, including a couple of minor corrections.

In our main article this month we share a guest article by John Taylor of TR Control Solutions. In this article, John outlines a sometimes hidden source of cycle time problems in wafer fabs: managing gases and chemicals. Expirations and stockouts of gases and chemicals can result in downtime and / or yield problems, both of which, as we well know, can contribute to wafer fab cycle time. TR Control Solutions offers a commercial product to help manage gas and chemical usage and expiration data. We imagine that many of you have your own solutions, and we welcome your feedback as we discuss this new-to-us fab performance management challenge.

Implementing OEE for Cluster Tools (Issue 16.06)

In this issue we have a quick announcement about recent and upcoming Fab Owners Association events, as well as an announcement about our latest software release. Our software tip of the month is about understanding the different types of cycle time reported in the software. We have no subscriber discussion this month.

In our main article this month we discuss some computational issues that have arisen as we have worked with several of our customers to implement cluster tool OEE. We share our approaches to dealing with these very nuts-and-bolts issues, and hope that this article will be useful to those of you working on cluster tool OEE.

Identifying Sources of Arrival Variability (Issue 16.05)

In this issue we have a community announcement about the next Fab Owners Association meeting. Our software tip of the month is about navigating the different “Go” buttons within the FabTime user interface. We have no subscriber discussion this month (though we would certainly welcome your questions or suggested discussion topics for the next issue). In our main article, we provide some specific answers to the question: how do I identify the sources of arrival variability to a particular toolgroup?

Motivational Aspects of Goal-Setting for Wafer Fabs (Issue 16.04)

In this issue, we have a call for papers for ISMI 2015, to be held in South Korea in October. Our software tip of the month is about using the new chart gridlines feature in FabTime. Apparently many people are on vacation (or otherwise engaged) because we have no subscriber discussion topics in this issue. Perhaps our main article will prompt some discussion going forward.

In our main article, we discuss the motivational aspects of goal-setting for wafer fabs. We investigate in particular the concept of SMART goals, a methodology that has been applied to a variety of industries. We apply the SMART methodology to wafer fabs, identifying what we believe to be the core motivational issue in goal-setting for fabs. We also discuss other potential pitfalls.

Balancing Fab Cost and Cycle Time (Issue 16.03)

In this issue we have a call for papers for a joint symposium between eMDC2015 and ISSM2015. Our FabTime software tip of the month is about identifying the tool that experienced the most time waiting for parts. In our subscriber discussion forum we have one response to the previous newsletter main article, and two responses to a subscriber discussion topic about balancing cost and on-time delivery.

In our main article, we take a more short-term look at balancing cost and cycle time in wafer fabs. We start by looking at the strengths and weaknesses of several possible approaches, and then focusing on how one might use actual historical data to help balance cost and cycle time at a tactical level. We welcome additional feedback on this complex and mission-critical topic.

Using WIP Turns for Forward Cycle Time Estimation (Issue 16.02)

In this issue we are pleased to announce the 16 year anniversary of FabTime, which we are celebrating by kicking off our 40th software installation. We also have an announcement from the Fab Owners Association about a new Packaging and Test group within the FOA. Our software tip of the month is about re-setting the default sort order for a chart. We also have a new subscriber discussion topic about balancing competing priorities of cost vs. on-time delivery in fabs.

In our main article this month we discuss the use of WIP Turns to generate forward estimates of fab cycle time. We discuss the benefits of this information, as well as related computational issues.

Goals for Fab Leadership to Drive Cycle Time Improvement (Issue 16.01)

Our one announcement this issue is about the conversion of the text email newsletter to an html format. Our FabTime software tip of the month concerns setting default filters for FabTime charts.

We have two subscriber responses to a topic raised in the last issue: setting goals for fab cycle time and on-time delivery improvement. We thought that these responses were so useful that we have shared them and expanded upon them as our main article. We derive a brief framework for setting fab management goals at the strategic, tactical, and operational levels, with special attention to the “Prisoner’s Dilemma” that can arise between shifts. As always, we welcome your feedback. We would be more than happy to continue this topic going forward, as we believe it has relevance to a large portion of our subscribers.

How Can We Get Better at What We Do? (Issue 15.06)

In this issue, we have an announcement about new FabTime software training videos that are available to our customers, as well as an announcement about the availability of the new SEMI E10 and E79 standards. Our FabTime software tip of the month is about editing the appearance and content of individual charts. We also have one subscriber discussion topic, concerning improving cycle time and on-time delivery for a fab.

In our main article this month we address the general question of how we can become better at what we do, whether what we do is manufacture computer chips, develop software, or something

else altogether. We revisit Deming's Plan-Do-Check-Act cycle, discuss several projects that we are working on internally to make our own company more productive, and then discuss the necessary steps for planning cycle time improvement initiatives.

Using Trend Lines to Enhance the Value of Dynamic X-Factor Charts (Issue 15.05)

In this issue we have a community announcement about the next Fab Owners Association meeting. Our software tip of the month is about navigating the different "Go" buttons within the FabTime user interface. We have no subscriber discussion this month (though we would certainly welcome your questions or suggested discussion topics for the next issue). In our main article, we provide some specific answers to the question: how do I identify the sources of arrival variability to a particular tool group?

Identifying and Solving Problems in Wafer Fabs (Issue 15.04)

In this issue we have three announcements: one about a new FabTime User Group started by the Fab Owners Association IE Team; one a call for papers; and one about an update to the SEMI E10 and E79 standards. Our FabTime tip of the month concerns the use of Tab Filters to change a filter setting for all charts on a home page tab on the fly. In our subscriber discussion forum we are pleased to announce a winner in the challenge issued by Frank in the last issue.

In the last newsletter, we talked about helping people to become better problem-solvers. In our main article this month, we review some of the many problems that there are to solve in wafer fabs. We group these issues under categories including capacity planning; starts planning; dispatching; and operations. While space does not permit us to delve into all of these questions here, we do seek your feedback regarding which of these problems would be most beneficial to work on going forward.

Helping People to be Better Problem-Solvers (Issue 15.03)

In this issue we are pleased to announce the release of our latest FabTime software patch, chock-full of useful enhancements, including the highly anticipated JavaScript charting engine. We also have a call for papers for the ISMI2014 conference. Our FabTime tip of the month is about predicting which lots will ship this week, and viewing their expected on-time performance. We also have one subscriber response to the last issue, on lot size changes.

In our main article this month, we offer some suggestions for helping people to become better problem-solvers. This is something we have been working on internally at FabTime, and we felt that some of our subscribers might find our advice useful. In particular, we focus on the need to question assumptions, and on the benefits of digging down to detailed data, rather than trying to solve problems based on top-level results.

Impacts of Changing a Fab's Lot Size (Issue 15.02)

We have two announcements in this issue, one about a promotion for Lara Nichols, now our Director of Engineering, and another with a call for papers for the MASM conference. Our FabTime

tip of the month is about identifying the states in which your bottlenecks spend the most time, so that you can seek opportunities for improvement. We have two subscriber discussion topics, one from Mike Hills in response to our last issue, and one with a new question about maintenance staffing models.

In our main article this month, we revisit and generalize upon a topic first introduced in the newsletter in early 2000: the impact of changing a fab's lot size. Where previously (in Issue 2.02) we had looked at the question of whether a lot size reduction was likely to be beneficial overall, in this new article we discuss both lot size reduction and lot size increase.

Dispatching and Line Balance (Issue 15.01)

We have one announcement in this issue, about the upcoming Fab Owners Association Collaborative Forum. Our tip of the month is about identifying the lot that has been on hold the longest in your fab (the first of a new series of step-by-step skills instructions that we are working on). We have two submissions from subscribers, one about foundries and cycle time, and the other about the impact of increasing lot size.

In our main article this month, we present the results of a series of simulation experiments conducted by FabTime's Mike Krist and Frank Chance. The goal of this experiment was to evaluate the impact of several commonly-used dispatch rules on linearity of shipments. The results showed that, of the rules tested, some had problems with WIP bubbles. This was initially less apparent under critical ratio dispatching than the other rules. However, in the presence of late lots, WIP bubbles were also observed under critical ratio. We believe that these results call for further investigation of line balance-focused dispatching.

Why I'm Still in the Industry after 30+ Years, by Frank Chance (Issue 14.06)

In this issue we have a brief recap of our September user group meeting, as well as an announcement about a new LinkedIn group that we've started for our software customers. Our software tip of the month is actually a list of 10 useful things that you can do with FabTime. In our subscriber discussion forum we have one response to an ongoing discussion of factors contributing to high cycle times in fabs.

Our main article this month is a bit of a change from our usual topics. FabTime's Frank Chance has taken his introductory remarks from our User Group Meeting and turned them into an article. Frank reflects on his 30 years working in the high-tech industry, particularly the breathtaking pace of performance improvement in data storage. He compares this rate of innovation to the automobile industry, and also discusses some of the new applications that are enabled through access to inexpensive data storage.

Six Sources of Equipment Variation and How to Control Them (Issue 14.05)

In this issue we have the final agenda for our first-ever User Group meeting. Our software tip of the month for this issue is about using FabTime's new Tool Count trend and pareto charts to track the number of down tools by category (e.g. number of tools waiting for parts).

In our subscriber discussion forum, we have two responses to last month's article about factors that contribute to fab cycle time. That article also inspired V.A. Ames of the SEMATECH Manufacturing Technology Center to offer to write a guest article about the six sources of equipment variation and ways to control them. After noting that the number one reported impact to fab cycle time continues to be equipment downtime and availability variability, V.A. elected to share his experience and "provide some insight into what needs to be done to lessen the impact of equipment variation on cycle time." We believe that many of our subscribers will find food for thought in this article.

Factors Contributing to High Cycle Times in Fabs (Issue 14.04)

In this issue we have two FabTime announcements, one about a new software release, and one about the status of our user group meeting plans. Our FabTime user tip of the month is about using a new filter auto-complete functionality. Our subscriber discussion forum has a response to recent articles about reentrant flow, as well as a newly introduced question about making decisions when key staff members are not available.

In our main article this month, we share the results of the informal survey of cycle time-related issues that we have been conducting for the past 10 years. Specifically, we list the top 30 issues cited by people filling out forms on our website, in response to open-ended questions. In part because the top items on this list have not changed much over the years, we feel that this list suggests improvement opportunities to a number of fab stakeholders. We welcome your feedback.

Why Should Foundries Care about Cycle Time? (Issue 14.03)

In this issue, we are pleased to announce that the registration form for the first FabTime User Group meeting is now available. We also have a FabTime installation success story from one of our customers, and a call for papers for the 2013 APC Conference. Our FabTime user tip of the month describes the new dynamic search feature on the FabTime charts page. We have no subscriber discussion this month.

In our main article, we address a question raised by a new newsletter subscriber: Why should foundries care about improving cycle time? While acknowledging that cycle time motivations for pure-play foundries may be different from those of independent device manufacturers (IDMS), we propose several reasons why foundries should be focusing on cycle time improvement also.

The Hawthorne Effect, Revisited (Issue 14.02)

In this issue, 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?

Overcoming Productivity Losses During Shift Change (Issue 14.01)

In this issue, we have one community announcement about a new production planning and control book published by three very long-time newsletter subscribers. Our software user tip of the month is about using the A20/A80 metrics to improve availability variability for tools. We have no formal subscriber discussion in this issue, but we have posed a few questions, in the hope of sparking some discussion for the coming year.

Our main article this month is about overcoming productivity losses that may occur during shift change. Whenever operators are measured (even self-measured) on move completions, there is a natural incentive not to start lots running that will not finish before the end of the shift. This leads to lost capacity on tools, as well as increased arrival variability to downstream tools. FabTime has been working with Cypress Semiconductor to develop a metric, called Earned Plan Hours, which attempts to overcome this behavior. As always, we welcome your feedback.

Fab Variability and Reentrant Flow (Issue 13.04)

In this installment we have an announcement about a new issue of Future Fab International. Our FabTime software tip of the month is about setting time windows for individual alerts. We have no new subscriber discussion topics. However, our main article this month was written by long-time newsletter subscriber Mike Hillis from Spansion. Mike's article is a detailed response to the topic of reentrant flow introduced in Issue 13.3. Mike discusses the way that variation in the fab makes it difficult to achieve planned output at reentrant tools (particularly nested reentrant tools, and particularly for fabs using critical ratio dispatching). He shares a solution that has worked for his company to keep WIP flowing linearly through the fab.

Reentrant Flow and Fab Cycle Time (Issue 13.03)

In this issue of the newsletter, we have an announcement about a new member of the Fab Owners Association. Our FabTime tip of the month is about understanding how actual and planned XFactor values are used in FabTime. We have two subscriber discussion submissions; a follow-on to the main article in the last issue about choosing the appropriate level of capacity planning: and a new question about downtime reason codes.

In our main article this month, we take a look at the reasons that reentrant flow makes managing cycle time and WIP in wafer fabs challenging. We first focus on the fundamentals - the ways that multiple visits to the same tool affect utilization, number of tools, and variability. We then explore some of the ways that reentrant flow affects capacity planning and dispatching.

What Level of Capacity Planning is Right for My Fab? (Issue 13.02)

In this issue, we have a community announcement about the new issue of Future Fab International (and an article within it about cycle time and variability by one of our newsletter subscribers). We also have a call for papers for the e-Manufacturing & Design Collaboration Symposium 2012. Our FabTime user tip of the month is about using the new average WIP lines on the Moves Trend and Pareto charts. We have subscriber discussion related to the economic benefits of cycle time improvement, the impact of engineers on cycle time, and the reasons that reentrant flow in fabs contributes to high cycle time and WIP.

Our main article this month is a guest article by Bob Kotcher of Simitar, Inc. Bob writes about choosing the appropriate level of capacity planning (from a simple static model to a highly detailed dynamic model) for each fab. He discusses investment in additional capacity for cycle time improvement in general, and highlights the need to focus on the question that the capacity model is being asked to solve. He concludes that "Millions of dollars can be left on the table by building models that are too basic. On the other hand, even the most detailed model is useless if it's unfinished or resources are not available to keep it accurate." We hope you find this article of interest.

Variability Metrics for Fabs: Part 2 (Issue 13.01)

In this issue we have a link to a news story from the Wall Street Journal that references Little's Law (one of the fundamental drivers of fab behavior), a call for papers for the MASM 2012 conference (to be held in Berlin in December), and an announcement about recent and upcoming Fab Owners Association meetings. Our FabTime user tip of the month is about using new stacked WIP and Moves charts. We have an extensive amount of subscriber discussion in this issue. Apparently, December's topic of metrics for fab variability was of particular interest.

In our main article this month, we share six potential variability-related metrics, inspired by subscriber and customer suggestions. These range from tracking first pass success rate for preventive maintenance events to aggregating lot slack times across tools or areas in the fab. It is clear from the broad response to this topic that many of us are working on finding new metrics to reduce variability in the fab. It is our hope that, together, through discussions like the ones shared below, we can work to find better solutions. We are grateful to all of the people who took time to share their thoughts on this topic, and welcome additional feedback.

Variability Metrics for Fabs: Part 1 (Issue 12.06)

In this issue, we have an announcement about a change to our tip of the month email list (a separate subscription from the newsletter, for customers). Our FabTime tip of the month is about identifying top causes of equipment downtime. In our subscriber discussion forum we have two responses to last month's question about capacity planning for cascading tools.

In our main article this month, we focus on metrics for fab variability. This article was inspired by informal discussions with several people at the November Fab Owner's Association meeting in Austin, Texas. These discussions encouraged us to consider whether we are providing the best toolkit that we can in FabTime in terms of fab variability metrics. We review the sources of variability in fabs, and our current approach for tracking fab variability, and propose a brief

variability sources snapshot report. We seek our subscribers' feedback regarding other metrics that should be added to this fab variability toolkit.

Using OEE to Enhance Factory Performance (Issue 12.05)

In this issue, we have community announcements about the upcoming Fab Owners Association meeting at Spansion, and a call for editors for the International Journal of Production Research. Our FabTime software tip of the month is about setting default filters for charts. This month's subscriber discussion forum includes several responses sparked by the main topic of the last issue, PM Scheduling. We also have a new question about capacity analysis for cascading tools.

Our main article this month is about using OEE to enhance fab performance. Recently, in response to a suggestion from one of our customer sites, FabTime changed the method by which we calculate OEE (Overall Equipment Effectiveness) Loss Factors. Several of our customers were interested in the details of not only the equations used; but also the methodology of using OEE to improve operations. In this article we discuss the definition and calculation of OEE, introduce FabTime's current methodology for calculating OEE Loss Metrics, and review how to properly use the information provided by OEE to continuously improve an organization's manufacturing capacity.

PM Scheduling and Cycle Time (Issue 12.04)

We have a community announcement about two new FabTime employees in this issue. Our FabTime user tip of the month is about setting a default home page tab for login. In our subscriber discussion forum we have two responses to last month's article about queueing models for wafer fabs, as well as a new question about measuring coefficient of variation for effective process times.

Our main article this month is about PM scheduling. Equipment downtime in general is one of the top contributors to fab cycle time. Scheduled downtime, and more specifically preventive maintenance, contributes to fab variability, but is somewhat controllable. It's possible to take the cycle time impact into account when deciding whether or not to group maintenance events, and thus minimize the impact of the scheduled maintenance. In this article, we discuss ways to do that.

Queueing Models for Wafer Fabs (Issue 12.03)

In this issue, we begin with a call for papers for the ISMI Symposium on Manufacturing Effectiveness. Our FabTime user tip of the month is about using a PowerPoint add-in to display live FabTime charts (mixed with other content) on monitors. In our subscriber discussion forum we have inputs on analyzing staffing productivity, embracing the downturn, and scheduling in the lithography area.

In our main article this month we discuss the application of queueing models to wafer fabs. We begin by outlining the benefits and drawbacks of queueing models (as compared with static models and with simulation). We then discuss tool group-level models, as implemented in FabTime's operating curve spreadsheet, as well as different approaches for constructing fab-level models. We conclude by discussing the simplified approach of using aggregated fab-level inputs in a simple G/G/c queueing model, and where this approach might, and might not, be useful. If any readers would care to share their experiences in applying queueing models to fab planning or operations, we will post those in a follow-up article. We welcome your feedback.

Ten Fab Management Discussion Topics (Issue 12.02)

In this issue we also have two calls for papers for conferences. Our FabTime user tip of the month is about ways to export full chart datasets to Excel. In our subscriber discussion forum we have two responses to last month's question about managing in the presence of multiple constraints, and a follow-up from Bob Kotcher to last month's main article about confidence intervals vs. prediction intervals.

In our main article this month, we have provided a forum for re-introducing a number of previously raised subscriber discussion topics. Our hope is that some of you will find that you have something to say on one or more of these topics, so that we can all learn from one another as a community. We welcome your feedback.

Prediction Intervals vs. Confidence Intervals (Issue 12.01)

In this issue we have three announcements, one about a survey from WWK, another with a call for papers, and the third about staying in touch with FabTime via my LinkedIn profile. Our software tip of the month is about using the new lot line yield charts in FabTime. We only have one subscriber discussion question, but it is quite detailed (about fab management in a multi-constraint environment).

In our main article this month, we address the difference between confidence intervals and prediction intervals. Both can be applied to simulated or actual recorded data, anything where you have repeated, variable observations (cycle times, WIP, etc.). Confidence intervals are used to estimate an underlying value that can't be directly observed, like the "true" mean cycle time for a product line. Prediction intervals, instead, are used to establish a range in which it is likely that a future observation will occur, given a series of past observations. So, for example, you might use a prediction interval to predict the upper and lower bound of expected fab throughput next week. We hope that you'll find this discussion useful.

Time Constraints and Reverse Dispatch in Fabs (Issue 11.05)

In this final newsletter issue of the year, we have community announcements about Future Fab International's new email publication, and the Fab Owners Association upcoming member meetings. Our FabTime user tip of the month is about adding complex logic within standard filters, using the new in-filter WHERE clause. We have subscriber discussion related to early lot delivery times, OEE, and the number of columns in the PDF newsletter.

In our main article this month, we discuss the application of "reverse dispatch" in the presence of time constraints between process steps. Where there are time windows between steps, lots are usually held at the upstream step, and only released when needed by the downstream step. This poses an implementation issue for dispatch systems, which usually look at one tool at a time. What FabTime has been working on is a system called "reverse dispatch", by which the person running the downstream tool can look back at all of the WIP queued at the upstream tool, and then make the best dispatching decision for both steps.

Early Delivery Times in Wafer Fabs (Issue 11.04)

In this issue, we have a community announcement about a new position for Professor Scott Mason. Our FabTime User Tip of the Month is about using the Quick Jump feature to navigate within FabTime. We have several subscriber discussion topics, ranging from a couple of changes requested in the newsletter format to responses to the topics raised in the last issue (OEE and capacity planning). We welcome your feedback.

Our main article this month sprang from a subscriber discussion comment about the importance of tracking lots that are early. In most fabs that we've observed, lots that are late garner a lot of attention, while lots that are early exit without fanfare. It turns out, however, that early lots can be a symptom of an underlying problem, such as too wide a distribution of cycle times, or inaccurate planning models. In this article, we discuss both the underlying fab behavior that contributes to early lots (including a brief mention of hot lots), and list a few potential consequences of having lots be significantly early.

Computational Issues in Estimating OEE (Issue 11.03)

In this issue, we have three community announcements: the results of the raffle for a complete set of past FabTime newsletters; a notice about the upcoming Fab Owners Association meeting; and a conference announcement for the ISMI's Manufacturing Week. Our FabTime user tip of the month is about setting goals for Pareto charts. We also have one subscriber discussion question about data structures for capacity models.

In our main article this month we discuss some of the computation issues that go along with using OEE (overall equipment effectiveness) as a metric. At its simplest, OEE measures the actual good units produced on a tool relative to the most units that could have been produced on that tool if everything went perfectly (no scrap, no rework, no downtime, no wasted time). Much of the value of OEE lies not so much in the actual OEE values, but in analyzing the underlying components, and understanding why a particular tool is not performing as expected. We last wrote about OEE in the newsletter in detail back 2002. In this article, we revisit the basics of OEE, with emphasis on calculating OEE values from fab performance data. We also specifically address the issues of calculating OEE for batch tools and estimating planned OEE.

100th Newsletter Issue Celebration (Issue 11.02)

This is our 100th issue of the newsletter. Issue number 1.01 was sent out on April 14th, 2000, to 33 subscribers from 17 different companies and universities (plus several consultants). Some of those initial companies don't even exist anymore, while others have merged and split and changed almost beyond recognition. It's hard to keep track. But we're happy to still number some of those initial subscribers among our current 2731 newsletter recipients. And, given the year that the semiconductor industry went through last year, we're happy to still be here. For our main article this month, we'll be revisiting the 10 years of newsletter issues, in a bit of a 100th issue celebration.

In this issue, we also have a call for papers for the 6th International MASM Conference and links to several recent news articles that we thought that our subscribers would find of interest. Our FabTime user tip of the month is about using customized text in email alerts.

Product Mix and Cycle Time Revisited (Issue 11.01)

In this issue, we have two community announcements, and one response to a previously introduced subscriber discussion topic. Our FabTime user tip of the month is about using the new Forecast Arrivals Charts to predict future arrivals to a particular tool or step.

In our main article this month we return to a topic first discussed five years ago, the effect of product mix on fab cycle time. Our return to this topic was triggered by a question raised in discussion with a friend: Is it inevitable that cycle time increases as you add technology mix to an existing fab (because you have more dedication, smaller tool groups, tools at higher utilization, more setups, smaller batches, etc.)? In light of this question, we have revised and expanded our previous thoughts on product mix and cycle time, and added some new suggestions for mitigating the negative effects.

Improving Factory Cycle Time through Improvements at Non-Bottleneck Tools (Issue 10.09)

Our FabTime user tip of the month is about reporting open lot cycle times. We have one community announcement, about ISS Europe 2010. We also have a new subscriber discussion topic (well, something that we haven't discussed in several years): operator productivity metrics.

In our main article this month, we return to something that we think is important for cycle time improvement efforts, but that we haven't discussed in detail since Volume 1 of the newsletter: cycle time improvement at non-bottleneck tools. It's well-known that in order to increase overall capacity in a fab, it's necessary to focus on the bottleneck (or bottlenecks, in most cases). However, when seeking to improve cycle time, it's possible to make improvements at tools that aren't capacity bottlenecks, and see improvement in overall cycle times. In this article, we explore the impact of improvement at non-bottleneck tools in a reentrant environment, and then offer concrete suggestions for deciding where to begin and taking action.

The Hawthorne Effect Revisited (Issue 10.08)

In this issue, we have only one brief community announcement, about FabTime's sponsorship of the coming Fab Owners Association golf tournament. Our software user tip of the month is about our new custom chart feature. We have subscriber discussion concerning dispatch execution / dispatch compliance, and target percentages of hot lots in the fab.

In our main article this month, we revisit and refresh our very first newsletter topic. The Hawthorne Effect, based on studies that took place at the Western Electric plant in Hawthorne, Illinois, suggests that worker productivity improves as a result of workers having their performance monitored, and then working harder. Although the Hawthorne Effect was formulated in the early 1920's, it remains of interest today. There continues to be debate over whether or not the Hawthorne Effect is "true". That is, people question whether in fact the productivity improvements recorded could be rightly attributed to the study at all. FabTime's feeling is that the general conclusion, that people will work harder if management pays attention to their outcomes, is intuitive and valid. For those who believe this, too, we've included some recommendations for leveraging the Hawthorne Effect in wafer fabs.

Using Short-Term Indicators to Improve Long-Term Performance (Issue 10.07)

In this issue, we have announcements about registration for two upcoming industry conferences, a new member of the Fab Owners Association, and a new issue of an industry publication dedicated to cost modeling. Our software user tip of the month is about filtering the WIP line on the tool state charts in FabTime (and other modifications to the tool charts). Our subscriber discussion forum this month has two responses to last month's main article about forecasting lot completion dates. We expect readers to find these responses quite useful.

In our main article this month, we discuss a central management issue in running wafer fabs, the constant need to translate short-term signals into actions to drive long-term goals. Of course, the translation of longer-term goals into shorter-term actions is a task that people undertake every day, in many areas of their lives. This task is particularly complex in wafer fabs, however, because of the high volume of data available, and the high degree of complexity and variability. In this article, we discuss some of the real-time signals that indicate problems in fabs, as well as some intermediate goals that are used as early warnings regarding longer-term goals. Our conclusion is that while access to good data is essential in translating from short-term signals to long-term goals, the human element remains necessary, too.

Forecasting Lot Completion Dates (Issue 10.06)

In this issue, we have two announcements, one about a book focused on improving factory performance, and the other about registration for the upcoming ISMI Manufacturing Week in Austin, TX. Our software user tip of the month is about using the new "export all data" capability in FabTime. We also have one subscriber discussion topic, about bringing a fab back up to full speed after a slowdown. We hope that this question will be relevant for many of you in the coming months.

In our main article, we discuss forecasting of lot completion dates. We believe that projecting shipment dates for individual lots is likely to become increasingly necessary for fabs. In this article, we offer a general method for predicting lot shipment dates using the sum of planned cycle times by step. We review several implementation details, particularly in regards to computing the step-level cycle times, and varying x-factors to account for changes in lot priority. We also briefly touch upon estimating earliness or lateness for in-progress lots, by comparing actual cycle time to expected cycle time to this point.

Problems that Stem from Broken Assumptions (Issue 10.05)

In this issue, we have two brief community announcements, and a response from a subscriber to two previously introduced discussion topics (dispatch precision and tool state reporting). Our FabTime software user tip of the month is about using the alert functionality in FabTime to send alerts to other people from your team.

In our main article this month, we discuss problems that can stem from broken assumptions. Whenever you implement a series of steps, whether this is in software code, a spreadsheet, or an operational process in a fab, you make assumptions along the way. Often these assumptions seem

so obvious that you don't even document them, let alone plan for them to be broken. But of course sometimes they do break. When that happens, the root cause is often difficult to identify. We decided to open up a dialog with our newsletter subscribers on this issue of broken underlying assumptions.

Responses to Four Recent Discussion Topics (Issue 10.04)

In this issue, we have two conference announcements, one about the IMEC Technology Forum scheduled for Brussels in June, and another about the AEC/APC Symposium scheduled for Michigan in September. Our FabTime user tip of the month of the month is about using new average WIP Trend and Pareto charts in FabTime (and using the same averaging functionality in the WIP Turns charts).

This month we have rolled the subscriber discussion section into the main article. We have four interesting and detailed discussions ongoing with subscribers related to: dispatch precision (a dispatch compliance metric); equipment uptime reporting (the main topic of the last issue); granularity of tool state reporting and modification of transactional data; and calculation of degree of lateness for in-process lots. In light of the substantive nature of these discussions (and with many thanks to the subscribers who have contributed), we've decided instead of a new main article to simply highlight these four topics.

Equipment Availability versus Equipment Uptime and Manufacturing Time (Issue 10.03)

In this issue, we have two announcements, one concerning social networks, and the other a call for papers. Our FabTime user tip of the month of the month is about identifying cumulative cycle time contributors, across the lifetime of lots. In this month's subscriber discussion forum, we have two responses to topics raised last month (dispatch compliance metrics and correlation in wafer fab data), as well as a new subscriber question about tracking of late lots.

Our main article this month is a relatively brief discussion of equipment state and availability-related definitions. We review the SEMI E10 definitions for equipment states, and discuss our intention to transition from using the term "Availability", which is not defined in terms of the E10 tool states, to using separate terms relevant for maintenance personnel vs. manufacturing personnel. For maintenance effectiveness tracking, we will use the metric Equipment Uptime (Productive + Standby + Engineering), reflecting the time that the tool is available for either production or engineering use. For manufacturing personnel, however, we will continue to report Manufacturing Time (Productive + Standby), which is the time that the tool is available for manufacturing use. It is, of course, the utilization of this Manufacturing Time that drives cycle time performance.

Correlation in Wafer Fab Data (Issue 10.02)

In this issue, we have two community announcements (one about an industry survey and another about an industry-specific networking site). Our FabTime software tip of the month is about identifying current top cycle time contributors in a fab. We have no subscriber-submitted discussion, but we have introduced a new topic (dispatch compliance reporting).

In our main article this month, we discuss potential charts to explore data correlation in wafer fabs. We begin with a general discussion on correlation vs. causation, and then propose several potential data pairing that we think would be useful in increasing our understanding of fab behavior. These range from the obvious example of looking at tool group cycle time vs. utilization to less obvious examples, such as overall fab cycle time vs. number of current single path operations. We hope that this article will stimulate discussion among our subscribers on data relationship in the fab.

Setting WIP Goals in Wafer Fabs (Issue 10.01)

In this issue, we have two community announcements, one about a special issue of Future Fab magazine, and the other a call for papers for the next MASM conference. Our software user tip of the month is about analyzing MTBF and MTTR data in FabTime. We have no subscriber discussion this month, but we have listed some recent topics, and welcome your feedback for future issues.

In our main article this month, we return to a topic addressed in Volume 9, Number 9, controlling WIP in the fab. In that previous article, we discussed the management of WIP bubbles. In this article, we discuss setting goals for WIP in the fab as a whole, and by area, and the tracking of the absolute delta from WIP goals as a measure of variability. We also discuss the importance of ensuring that WIP goals are consistent with other fab goals, and illustrate this with a detailed example. While WIP levels are probably declining right now in many fabs, we reiterate the point from last month that a downturn is a good time to focus on fundamentals. Understanding and tracking your WIP levels in more detail is a good place to start.

Improving Cycle Time during a Downturn, Redux (Issue 9.10)

In this issue we have an announcement about the upcoming Winter Simulation Conference, and a subscriber discussion question about success stories in implementing lean and six sigma techniques in wafer fabs. Our software user tip of the month is about looking at variation from a WIP goal. Continuing this theme of looking at WIP variation, our main article discusses WIP bubbles in wafer fabs. A WIP bubble is a larger-than-normal buildup of WIP at a particular point in the line. WIP bubbles result in large queues in front of a few tools, while other tools, sometimes even bottleneck tools, remain idle. A common goal in fabs is to smooth out the WIP bubbles, so that all production areas remain relatively busy. Smoothing of WIP bubbles improves cycle time by reducing arrival variability throughout the fab. In this article, we discuss techniques for avoiding WIP bubbles in the first place (where possible) and for coping with them when they do arise.

WIP Bubbles in Wafer Fabs (Issue 9.09)

In this issue, we have only one brief community announcement, about FabTime's sponsorship of the coming Fab Owners Association golf tournament. Our software user tip of the month is about our new custom chart feature. We have subscriber discussion concerning dispatch execution / dispatch compliance, and target percentages of hot lots in the fab.

In our main article this month, we revisit and refresh our very first newsletter topic. The Hawthorne Effect, based on studies that took place at the Western Electric plant in Hawthorne, Illinois, suggests that worker productivity improves as a result of workers having their performance

monitored, and then working harder. Although the Hawthorne Effect was formulated in the early 1920's, it remains of interest today. There continues to be debate over whether or not the Hawthorne Effect is "true". That is, people question whether in fact the productivity improvements recorded could be rightly attributed to the study at all. FabTime's feeling is that the general conclusion, that people will work harder if management pays attention to their outcomes, is intuitive and valid. For those who believe this, too, we've included some recommendations for leveraging the Hawthorne Effect in wafer fabs.

Tool State Calculations for Cluster Tools in Fabs (Issue 9.08)

In this issue, we have a community announcement about a deadline extension for abstracts for the Advanced Semiconductor Manufacturing Conference. Our FabTime software user tip of the month is about separating out the components of non-process time (queue time, hold time, etc.). We have no subscriber discussion this month. However, we do suspect that this month's main article will inspire some discussion for the next issue. We have asked occasional contributor Professor Scott Mason to write about tool state calculations for cluster tools. Professor Mason discusses two primary methods for estimating overall cluster tool performance, one based on logical rules and the other based on averages (possibly weighted) across chambers. He gives several examples, and shows through these examples how different the overall results can be depending on the calculation method used. He concludes that the wide disparity of results begs the question: how are cluster tool E10 states computed in your fab?

How To Extend the Life of Your Fabs? Measure, Monitor, and Control (Issue 9.07)

In this issue we have a brief announcement about the Fab Owners Association. Our software user tip of the month is about setting up home page tabs that update on a monthly (instead of a weekly or daily) basis. In our subscriber discussion forum we have a response to last month's article about measuring line yield, and an update on a previous discussion question about short-term fab simulation.

For our main article this month we have a special treat - a guest article by Dick Deininger and Rebecca Taylor of Taylor-Deininger Partners. The article is about measuring, monitoring, alarming and control actions that cut costs and increase productivity, to extend the lifespan of existing fabs. The article is specifically geared towards older fabs that are make products that "do not demand bleeding edge technology to be profitable... Taylor-Deininger Partners has developed a modeling capability to demonstrate the value of implementing remote monitoring in a number of application areas. The model analyzes current Fab wafer losses, die yield losses, gas usage, electrical usage, water usage, and air handling. It then estimates the value of implementing measurement, monitoring and alarming in the highest value areas. It can show how losses and usage of key materials can be reduced, thus improving productivity. The model shows that remote dynamic monitoring helps identify problems before they can adversely affect product. This paper describes a number of these situations with demonstrated savings in a number of ultra clean facilities involved in semiconductor manufacturing as well as laboratories."

Definitions for Short-Term Line Yield Metrics (Issue 9.06)

In this relatively brief issue we have no community announcements. Our FabTime user tip of the month is about using the SQL filter to remove outliers from a down tools list. We have one subscriber contribution, concerning the use of Dynamic X-Factor at On Semiconductor in Gresham. In our main article this month, we review potential definitions for short-term line yield metrics, definitions that take into account the particular complexities of wafer fabs. We are seeking input from the newsletter community because we would like to include one or more detailed definitions for line yield in FabTime's metrics lexicon. We believe that these definitions will be useful to the community as a whole.

Paper vs. Electronic Lot Travelers (Issue 9.05)

In this issue we have a community announcement about the third issue of Fab Engineering & Operations Magazine (a publication that's not affiliated with ours, but that we think our readers will enjoy). Our FabTime user tip of the month is about using FabTime's software to generate a list of lots ahead of or behind schedule, according to planned cycle times at future operations.

We have one new subscriber discussion question in this issue, about the use of short-term simulation. We also received several detailed responses to last month's question about the transition between paper and electronic lot travelers. In fact, these responses are so thorough, and varied, that we've decided to convert them into this month's main issue. This is a slightly unusual approach to our main article, but one that we think will prove useful to anyone facing this paper to electronic traveler transition. The strength of these responses also shows what a valuable resource this subscriber community can be. We are very grateful to the subscribers who took time to respond to this topic and to all of you who have helped us with prior discussions. We welcome further feedback on paper vs. electronic lot travelers.

Dynamic X-Factor and Shipped Lot X-Factor (Issue 9.04)

In this issue we have a brief summary of upcoming industry conferences in our community announcements section. Our FabTime software user tip of the month is about using the home page chart alert functionality. We have one subscriber discussion question, about the transition from paper to electronic travelers, for which we could use your input. Our main article this month is about the comparison between dynamic x-factor (a point estimate measured as total WIP divided by WIP running on tools) and shipped lot cycle time x-factor. We show that although in the long run, DXF can be used to predict x-factor, various issues sometimes make it difficult to draw exact comparisons between this week's DXF and some future week's shipped lot x-factor value.

Batch Loading Policies for Wafer Fabs (Issue 9.03)

In this issue, we have community announcements about the second issue of Fab Engineering and Operations Magazine and a milestone reached by the Fab Owners Association. Our software user tip of the month describes how to use FabTime's new Queue Limit Lot List chart, which shows the non-held lots in queue that have exceeded, or are in danger of exceeding, a user-specified threshold.

We have one subscriber discussion question this month, about batch loading rules. In responding to this question, we realized that it has been more than five years since we last discussed batching

in detail in the newsletter. Therefore, we decided to discuss batching in our main article this month. Specifically, we review the cycle time benefits of a greedy vs. a full batch policy, with examples, and also provide a simple rule of thumb for using look-ahead information in the batch formation decision. We welcome subscriber feedback, especially about experiences with greedy vs. full batch policies and incorporating look-ahead information into the batch loading decision.

Manual Lot Transfer in Wafer Fabs (Issue 9.02)

In our main article, we discuss lot transfer between operations for non-automated fabs. Although material handling in automated fabs has gained considerable attention in the literature, we believe that lot transfer is also having a significant impact on cycle time in less automated fabs, and that this topic is relevant for many of our newsletter subscribers. Behaviors such as the use of carts for lot transfer and the use of performance incentives for operators that do not reward the movement of material between areas can lead to higher than anticipated cycle times. For those fabs that are experiencing delays due to lot transfer, we recommend working towards reducing transfer batch sizes between steps, either by physically purchasing smaller carts, or by changing the way that operators are assigned or measured. If a full-scale change in carts or operating practices is not possible, we recommend identifying the specific areas in which material movement issues are causing cycle time, and implementing changes in those areas first. We discuss these potential solutions in detail, and welcome feedback. We also have one community announcement - a call for papers for the 2008 MASM conference. Our software user tip of the month is about showing and hiding data table columns in FabTime. We have no subscriber discussion this month.

Our Top Recommendation for Cycle Time Improvement: Tackle Single Path Operations (Issue 9.01)

We have one brief community announcement this month, about the winter Fab Owners Association meeting. Our FabTime software user tip of the month is about eliminating time spent with particular hold codes or owner codes from Operation Cycle Time Trend and Pareto charts. We also have a subscriber discussion response from Dov Kotlar of Tower Semiconductor (one of our software customers) to some previous questions that we raised about cycle time benchmarking.

In our main article this month we return to a topic that we have discussed before, but that continues to pose challenges for people who manage wafer fabs: single path operations. We review the different types of single path operations, and focus on those that stem from tool dedication. We present a rule of thumb for estimating the potential impact of going from single path to dual path for a given operation, and discuss two particularly insidious forms of tool dedication: soft dedication due to operator preferences; and process restrictions for new operations. In both cases, we recommend strategies for identifying and eliminating the single path operations. We believe that this is one of the highest benefit low-cost changes that an existing fab can make to improve cycle time.

A Fab Cycle Time Improvement Checklist (Issue 8.10)

In this month's newsletter we are pleased to announce a FabTime case study that was published by one of our suppliers. Our software tip of the month is about displaying chart data tables directly on FabTime home page tabs. We have a plethora of subscriber discussion in this issue, including a response to an ongoing topic about modeling cluster tool behavior, two responses to a question

about managing combined production and development fabs, and two detailed responses to last month's article about cycle time benchmarking.

In our main article this month, written by Frank Chance, we propose a fab cycle time improvement checklist. The idea is to help codify cycle time improvement practices, so that they become repeatable. The seven items in the checklist include identifying baseline cycle time metrics, finding metrics that indicate current and future cycle time problems, and looking for root causes. These, and other steps, are discussed.

Definitions for Cycle Time Benchmarking (Issue 8.09)

In this issue we have a brief followup to an earlier announcement, to remind you about the upcoming launch of the Fab Engineering & Operations Magazine, as well as a job change announcement from V.A. Ames. Our FabTime tip of the month is about the use of new formatting controls to enable smaller home page charts. We have subscriber discussion about managing production and development activities in the same fab, loading and managing batch tools, and varying lot sizes in the fab.

Because we have quite a bit of subscriber discussion this month, we bring you a relatively short main article. We discuss some of the challenges of calculating cycle time benchmark data. Specifically, we review the two primary metrics currently used for benchmarking across fabs and technologies, X-factor and days per mask layer (DPML), and discuss specific computational issues that apply to each one. We also discuss the conversion ratio between the two metrics. Our hope is that this article will spur further discussion, which will in turn help people who are looking to benchmark and improve their cycle times.

Wafer Fab Flow Control via Order Release (Issue 8.08)

This month we have community announcements about a FabTime demo offer and some upcoming industry meetings. Our FabTime software tip of the month is about using FabTime to predict when lots will complete processing in the fab. We also have some subscriber discussion regarding batch tools, a continuation of an earlier topic.

In our main article this month, written by Professor Scott Mason, we discuss the impact that the way lots are released into a wafer fab can have on performance. We provide an overview of workload (flow) control terminology, and then briefly discuss both push- and pull-based methods. Finally, after discussing recent results from case studies, we conclude by returning to last month's newsletter topic, dispatching in wafer fabs, to discuss advanced dispatching strategies for linked process steps. We conclude with three recommendations for evaluating lot release policies used in fabs.

Scheduling and Dispatching in Wafer Fabs (Issue 8.07)

In this issue, we have a community announcement about a new electronic publication that we think will be of particular interest to subscribers of this newsletter. It's targeted to established fabs, rather than focusing only on the bleeding edge of technology. Our FabTime user tip of the month concerns exploiting the archive of past FabTime tips from inside the software. We have two subscriber responses to last month's issue – one about holding batch tools idle, and the other about cluster tools.

Our main article this month comes from our esteemed guest contributor (introduced last month), Professor Scott Mason of the University of Arkansas. Professor Mason is a national expert on dispatching, scheduling and manufacturing performance improvement for wafer fabs. This month, Professor Mason discusses scheduling and dispatching. He provides an overview of scheduling and dispatching terminology, discusses the state of the practice with respect to fab dispatching, briefly outlines FabTime's dispatching functionality, and then presents some case study results from across the industry describing the positive impact that effective dispatching can have on a fab. We hope that you find this article useful, and we welcome your feedback.

Cluster Tools in Wafer Fabs (Issue 8.06)

In our community news section this month, we summarize information about four upcoming conferences that have relevance for fab manufacturing performance improvement. Our FabTime software tip of the month is about restricting FabTime data access for individual users. We also have a subscriber discussion topic, introduced by Walt Trybula, related to last month's question about fab utilization. This month's main article, about cluster tools, was written by Professor Scott Mason of the University of Arkansas, a national expert on dispatching, scheduling and manufacturing performance improvement for wafer fabs. He provides an overview of cluster tools, including a discussion of some of their pros and cons, and then discuss approaches (both academic and practical) for modeling and analyzing cluster tools in order to develop estimates of tool capacity and cycle time. He also shows, by example, the way that adding a chamber can sometimes increase capacity, while decreasing cycle time, for a cluster tool, by reducing blocking.

Conquering WIP Bubbles (Issue 8.05)

Our FabTime software tip of the month this issue is about using FabTime's new tool qualification charts to identify single-path operations in the fab. In our subscriber discussion forum, we have an extended discussion with Dov Kotlar of Tower Semiconductor about metrics for measuring fab utilization. In our main article this month we tackle the subject of WIP bubbles. People ask us occasionally: "how do I manage WIP bubbles in the fab?". A WIP bubble is a large pile of WIP, usually in queue at a particular tool-group or small set of tool-groups. WIP bubbles occur due to a variety of causes, the most notable of which is extended downtime on a one-of-a-kind tool. In this article, we discuss common causes of WIP bubbles, methods for avoiding them, early WIP bubble indicators, and potential methods for mitigating their effect. Several of the latter involve making dispatching decisions that encompass information about downstream operations. We hope that yo'll find this article useful, and we would love to hear your feedback.

Sources of Variability in Wafer Fabs (Issue 8.04)

In this issue we have a software user tip of the month about copying user accounts, and two subscriber responses to last month's issue about estimating operation-level cycle times. In our main article this month, we address sources of variability in wafer fabs. Variability is one of the main causes of fab cycle time. Variability affects the shape of the operating curve of cycle time vs. tool utilization. By reducing variability, we can move the knee of the operating curve for a fab, achieving a lower cycle time at the same throughput rate. Variability reduction is a relatively inexpensive way to improve cycle time, because it does not require the purchase of capital equipment, or any reduction in starts. However, in order to reduce variability in your fab, you need to be able to identify the specific sources of variability. In this article, we review some of the major

sources of variability in fabs, and suggest several general methods for reducing it. We then discuss in detail metrics that you can use for quantifying and identifying specific variability problems in your fab.

Estimating Planned Operation Cycle Times (Issue 8.03)

This month we have two community announcements and one response to last month's article about making morning meetings more effective. Our FabTime software user tip of the month is about tracking cumulative hold time across lots. In our main article this month we discuss the reasons for needing planned operation-level cycle time values, and review several potential methods for generating them. Methods discussed include using a straight multiple of theoretical, across all steps, using queueing or simulation models to estimate step-specific values, and using actual historical data. We then discuss some technical issues related to the use of actual data, specifically the selection of using mean or median value from a set of actual observations. We hope that you will find this discussion useful.

What Makes an Effective Morning Meeting? (Issue 8.02)

In our main article this month, written by Frank Chance, we discuss the ever-popular, but rarely examined in the literature, fab morning meeting. Nearly all fabs that we know hold a daily morning production meeting. Our hypothesis is that fabs that hold effective morning meetings are also likely to be effective at achieving their manufacturing goals. A morning meeting is effective if it routinely achieves it stated purpose, whether that is to distribute information, hold individuals accountable, make decisions, brainstorm solutions, or another purpose specified by fab management. In this article, we examine the purposes for morning meetings and explore behaviors that may make meetings ineffective. Our goal is to motivate you to examine and improve the effectiveness of your morning production meetings.

In this issue we also have a call for papers for the 2007 MASM conference, to be held in Scottsdale, Arizona in September. Our software user tip of the month involves using FabTime to track on-time delivery performance. We have no subscriber discussion, though we have been having some informal discussions with people about wafer size transitions and benchmarking, which may be reflected in future issues.

Highlighting Cycle Time Problems for New Products (Issue 8.01)

In our main article this month we address a problem that we've heard mentioned at several companies. The issue is that new, low volume products often incur long cycle times, because the traditional performance measures in fabs allow them to slip through the cracks. We present a series of recommendations for mitigating this effect. We welcome your feedback.

Our software tip of the month is about how to cross-slice move and WIP data in a single chart data table (to look at, for example, WIP by priority within each area on the same page). We have several subscriber discussion topics. Anonymous subscribers wrote in with new questions concerning justifying additional capacity to management and identifying and analyzing your own fab's top three cycle time problems. We also have a response from David Jimenez of WWK to a question posed last month about labor modeling for fabs.

In-Depth Guide to Cycle Time Management Resources (Issue 7.10)

In our main article this month, we have a special year-end write-up of industry resources on cycle time management for wafer fabs. We were inspired to put this together by various inquiries from subscribers about where to get started in learning about fab cycle time, and what to do to start a cycle time improvement project. People asked us about papers, conferences, software products, links, tutorials, and the like. Naturally, many of the resources that we have to suggest come from FabTime's own website, since we have been working in this area for seven years. But, in our travels, we've also come across other useful industry references, books, conferences, and sources for papers, and we wanted to share some of those with you. We hope that you find this article useful. We welcome your feedback and additional suggestions.

In this issue, we have a FabTime software tip of the month concerning use of a new priority-based alert. We also have two subscriber discussion questions: one about integrated metrology, and one about staffing models. We're pleased to introduce both topics, because subscriber discussion has been rather sparse lately, and we hope that some of you will choose to contribute. We also have a response to last month's article about "7 Things You Should Know about Wafer Fab Cycle Time."

Seven Things You Should Know About Wafer Fab Cycle Time (Issue 7.09)

In our main article this month was discuss seven things that we believe people need to understand in order to improve wafer fab cycle times. We focus on high-level items, areas through which fab management can have a significant influence. These include utilization, tool redundancy, equipment downtime, product mix, staffing levels, access to performance data, and selection of metrics. There are many other factors that influence cycle time in wafer fabs, too, of course (batching, setups, hot lots, and holds, just to name a few). But we think that the areas highlighted in this article are worthy of your time and attention. We welcome your feedback.

In this issue we also have a FabTime-related announcement, complete with a glowing endorsement from one of our newer customers. We also have one last conference announcement for the year. Our software user tip of the month concerns hiding chart legends on your FabTime home page. We have one subscriber response to last month's article about lot release policies. We're hoping that subscriber discussion levels will ramp back up in the future.

Ways that Fabs Create Arrival Variability (and Cycle Time) (Issue 7.08)

In our main article this month we discuss several ways that operating practices in fabs contribute to arrival variability, and hence to cycle times. These include releasing lots into the fab in large batches, forcing full batches on lightly utilized batch tools, and using carts for manual transportation of lots between steps. Each of these practices directly increases fab cycle time. We recommend relatively low-cost changes that, if implemented, can help to smooth the flow of WIP through the fab, and make cycle times lower and more predictable.

In this issue we have two announcements related to industry conferences. Our FabTime software user tip of the month is about how to look at shipped lot cycle times for individual lots in more detail. We have no subscriber discussion in this issue, but we do welcome your questions or comments for future newsletters.

Financial Justification for Cycle Time Improvement Efforts (Issue 7.07)

In our main article this month we provide some ammunition to the many people who have asked us for help in estimating financial benefits from cycle time improvement efforts. The dollar benefits from cycle time improvement are not as easy to estimate as those from utilization improvement. However, there are several clear benefits that stem from variability reduction and cycle time improvement. If we can reduce variability in the fab, we have the option of squeezing the existing capacity buffer, and getting some extra throughput out of the same toolset. Alternatively, if we reduce variability in the fab, we can reduce cycle time. Cycle time reduction is tied to several other benefits: improved line yield, decreased WIP carrying cost, decreased cost of engineering change notices, decreased risk of obsolete inventory, and increased revenue from time to market pricing premiums. In this article, we review the first two of these benefits in detail, with numerical examples, and include highlights of the other three.

In this month's issue we have a response from newsletter subscriber MS Ham to last month's question about making dispatching decisions that account for downstream batch efficiency. Our development team has also been busy, and our FabTime software user tip of the month concerns a new method for configuring flexible goals.

Resolving the Cycle Time vs. Utilization Conflict (Issue 7.06)

In our relatively short main article this month, we discuss a fundamental conflict in wafer fabs: the pressure to simultaneously increase tool utilization, while decreasing cycle time. As regular readers of this newsletter know, utilization is one of the main drivers of cycle time at the tool level. As utilization increases, cycle time increases non-linearly, becoming very large for tools with the highest utilization values. Despite this fact, fabs are under cost pressure to increase utilization, so that they can get more throughput out of the same toolset. In this article, we discuss two ways to resolve this conflict.

In this month's issue we have an announcement about my being named to the Supplier Advisory Board for the Fab Owners Association. The FOA is a corporation of semiconductor fab owners and associates who meet to discuss common manufacturing issues, and to combine strengths and resources. I recommend that you look into it, if you are an independent device manufacturer. We also have announcements for two upcoming industry conferences.

This month's FabTime software user tip of the month describes how to use our new Forecast Outs Lot List chart. In our subscriber discussion forum we have a response from a subscriber about an attempt to implement Kanban cards in a wafer fab (in response to last month's article about lean manufacturing). We also have a new subscriber question about making active dispatching decisions to improve downstream batch efficiency. We welcome your feedback regarding these topics, or your other manufacturing-related questions.

Lean Manufacturing and Wafer Fabs (Issue 7.05)

In our main article this month, we revisit a topic that we last touched in the very first year of publication of the newsletter: lean manufacturing and wafer fabs. Lean manufacturing is a philosophy focused on reducing waste and developing a more flexible and efficient manufacturing process. This philosophy has application to many types of manufacturing environments, including wafer fabs. However, many of the lean manufacturing implementation techniques currently in use were developed for automotive manufacturing, and are problematic when applied to wafer fabs. This does not mean that the underlying principles of lean manufacturing can't be applied to wafer fabs - merely that we have to look at the underlying techniques, and focus on more relevant industry-specific implementation methods.

In this month's issue, we have an announcement regarding the IEEE Robotics & Automation Society's Technical Committee on Semiconductor Manufacturing Automation. They have a useful new website available. Our software user tip of the month is about setting alerts for individual lots at specific operations, highlighting two new alerts requested by a FabTime customer. In our subscriber discussion forum, we have a response to last month's main article about cycle time variability. We're also pleased to welcome 11 new companies and universities to the subscriber list.

Cycle Time Variability (Issue 7.04)

This month we have an announcement about new members of the Fab Owners Association, of which FabTime is an associate member. Our FabTime software user tip of the month is about generating a lot comments report (to display all of the MES comments for a particular lot). We have subscriber discussion related to last month's question about process cycle efficiency, and about cycle time variability.

The subscriber discussion questions about cycle time variability, in conjunction with a discussion that we've been having with one of our customers, inspired us to write this month's main article about cycle time variability (or the distribution of cycle times). We first briefly discuss benefits of and methods for tightening the distribution of shipped lot cycle times. We then review a couple of metrics for tracking variability within the fab, with emphasis on understanding the impact of this variability on overall cycle time distribution. We next describe several methods for tracking and reporting shipped lot cycle time distribution, including a new metric similar to the A20/A80 availability metric, which we have called CT20/CT80. We believe that this metric can help fabs to better understand, and hence to improve, the distribution of lot cycle times.

Cycle Time Metrics Baseline (Issue 7.03)

In our main article this month, we summarize our current recommended set of metrics for managing and improving cycle time in a wafer fab. Metrics are an indication of management priorities. Fabs that are cycle time focused need metrics that drive cycle time improvement. Such metrics should highlight current opportunities for improvement, and, if followed, should lead to improvements in shipped lot cycle time. In this article, we discuss several metrics that we believe are helpful for cycle time improvement. We have categorized these metrics as open lot, closed lot, shift-level, and tool-level, and have briefly defined each one.

This month we have an announcement about the newsletter receiving its 2000th subscriber. We also have an announcement regarding future newsletter topics. Our FabTime user tip of the month describes the use of the new “stripe” control to apply a target band across a chart. We also have subscriber discussion regarding the continuing topic of M-Ratio (maintenance ratio), by James Ignizio, and about a cross-fab metric called Process Cycle Efficiency.

Operator Variability and Cycle Time (Issue 7.02)

In our main article this month we return to the ever-popular topic of operators. Specifically, we discuss some of the ways that operators can introduce variability into the fab and suggest metrics to capture and reduce this effect. It’s a relatively short article, in honor of our shortest month (and because of the extensive subscriber discussion in this issue).

This month we have two FabTime announcements, one about our new associate membership in the Fab Owners Association, and another concerning our enhanced lot dispatching module. We also have a call for papers for a special session on semiconductor manufacturing at the upcoming IEEE Conference on Automation Science and Engineering. Our FabTime software user tip of the month is about displaying zero-value objects on the move and WIP pareto charts. This month we have quite a bit of subscriber discussion, with multiple responses to last month's article about running development lots in a production fab. We also have multiple responses to James Ignizio’s description of M-Ratio from last month’s subscriber discussion forum.

Running Development Lots in a Production Fab (Issue 7.01)

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

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

Operational Recommendations for Wafer Fab Cycle Time Improvement (Issue 6.10)

In our main article this month, we have gathered a collection of operational recommendations and metrics for driving cycle time improvement efforts. We have heard from several fabs recently that they are planning cycle time reduction initiatives for the New Year, and we thought that this collection would be helpful. We include recommendations related to variability reduction, tool utilization (capacity loss), and tool qualification. We also briefly define 9 metrics and data sources useful for short-term cycle time improvement projects.

This month we have a job change announcement and a press release regarding a new version of our software. Also, due to positive response from our subscribers, we are repeating our offer of a free one-hour talk on cycle time management for fabs in the U.S. Our FabTime software user tip of the month describes a short-cut for home page management. This month we have subscriber discussion about WIP States and cycle time estimation formulas.

Estimating and Using Operation Cycle Times (Issue 6.09)

In our main article this month, we discuss uses for both actual and planned operation-level cycle time data. Actual values can be used to flag operations for which the ratio of cycle time to process time (x-factor) is higher than expected. Actual values can be compared with planned values, to identify short-term problems. Actual operation cycle times are also helpful in calculating planned cycle times. Planned cycle time values are in turn useful for estimating lot completion dates and facilitating dispatching decisions. In this article, we also introduce a new sidebar feature: a brief exercise for FabTime software users. Our goal is to make the newsletter articles more hands-on and relevant to our customers, the ones who make this newsletter possible.

This month we have an announcement and call for papers for a conference to be held in France in the spring. We've also provided a brief review of the ISMI conference held in Austin last month. We are also repeating an offer to give a free one-hour talk on fundamentals of cycle time management for fabs in the U.S. This month's FabTime user tip of the month is about clearing Internet Explorer's temporary file folder to improve FabTime performance. Our subscriber discussion forum is brief this month but contains an excellent extension to our WIP States proposal.

Cycle Time and Hot Lots Revisited (Issue 6.08)

In our main article this month we revisit the topic of hot lots. We talked about hot lots back in Issue 3.02, but thought that it was high time for a fresh look. This article is adapted from a section in our two-day cycle time management class, as well as from various discussions that we have had with our course and software customers. We discuss reasons for hot lots, the two primary types of hot lots, and the impact of hot lots on cycle time, and conclude with recommendations regarding hot lot management. We also include several references for further information on hot lots.

This month we are pleased to announce a free one-hour talk on cycle time management, which we are offering to deliver onsite for fabs in the U.S. We have several announcements related to conferences and journals. October seems to be a popular conference month! We also have a notice about two jobs that are available at a U.S. wafer fab. Our FabTime software tip of the month concerns independent sorting of chart and data table information. We have subscriber discussion related to two open topics: fundamental drivers of fab cycle time, and identifying the cause of declining moves in a wafer fab.

Setup Avoidance and Dispatching (Issue 6.07)

In our main article this month we discuss setup avoidance policies for lot dispatching. Where present, setups reduce the available capacity of tools, and tend to increase cycle time. This has led to frequent use of setup avoidance policies in fabs. However, running a pure setup avoidance policy can lead to long cycle times for low volume recipes. Various methods exist for forcing a setup to occur to prevent long queue times – several are discussed below. We also discuss

integration of setup avoidance into a dispatch factor paradigm, and parallels between setup avoidance and batch size formation decisions.

This month we have a conference announcement about ISSM, to be held in San Jose next week. Our software user tip of the month is a primer on using FabTime's Excel export functionality. We also have subscriber discussion related to identifying the cause of declining moves in a wafer fab and improving lot tracking in less automated fabs (both from Issue 6.06), and the fundamental drivers of fab cycle time (from Issue 6.05). A new subscriber discussion topic about formalizing methods for setting operation cycle time goals is also included.

Cycle Time and Holds (Issue 6.06)

Our main article this month is about the impact of holds on fab cycle time. This is not a topic that we've seen addressed in much depth in industry publications, despite being something that people who work in manufacturing deal with on a day to day basis. Holds negatively impact cycle time in two ways. First, the hold time itself is a direct addition onto cycle time. Second, holds increase variability in the fab, particularly when the time until a lot comes off hold is highly random. And as we know from our previous discussions, anything that increases variability in the fab is also increasing cycle time. We offer a few recommendations for managing holds, and we look forward to hearing your ideas.

This month we have an announcement about FabTime's sponsorship of the upcoming ISMI Symposium on Manufacturing Effectiveness. We hope to see you there! Our FabTime Software User tip of the month describes how to quickly view the status of all tools in a particular production area. We have no subscriber discussion this month.

The Three Fundamental Drivers of Fab Cycle Time (Issue 6.05)

In our main article this month we have opted to go back to basics. The article discusses the three fundamental drivers of cycle time at the tool level: utilization, variability, and number of qualified tools per tool group. We introduce each of these factors, reviewing why and how they affect cycle time. Each discussion concludes with suggestions for mitigating the effect of the factor, and hence improving cycle times. While we have discussed each of these issues in previous newsletters, this article brings the topic together into one convenient format. We do have a one-hour presentation that is similar to the content in this article. If you would like someone from FabTime to visit your site to give this talk (perhaps to help you to kick-start a cycle time improvement project), please contact us.

This month's FabTime user tip of the month is about setting up personal goals and displaying them on chart pages. We have subscriber discussion related to last month's article on lot dispatch for wafer fabs, as well as on the practical application of WIP turns and the cause of declining moves. We also have a conference announcement and call for papers for the 2006 Advanced Semiconductor Manufacturing Conference.

Lot Dispatch for Wafer Fabs (Issue 6.04)

In our main article this month, we discuss WIP management, with emphasis on lot dispatching. We begin by defining scheduling and dispatching. We then define several standard dispatch rules, and

examine the common factors underlying these rules. Finally, we briefly review some of the fab-specific issues that lend particular complexity to dispatching: batching, setups, and time constraints between process steps. This is far from being a comprehensive description of all of the possible fab dispatch rules. Instead, our intention is to introduce a common vocabulary for dispatching, so that in future discussions we can explore more complex scenarios. We welcome your feedback.

We are lacking in community announcements for this issue, but we do have subscriber discussion related to last month's article on overall WIP effectiveness, and a new question about troubleshooting declining moves in a wafer fab. Our FabTime software user tip of the month is about excluding extended holds for marketing purposes from the shipped lot cycle times reported by manufacturing.

A WIP-Centered View of the Fab: Part 2: Overall WIP Effectiveness (Issue 6.03)

In our main article this month, we continue last month's discussion of "A WIP-Centered View of the Fab". Last month we proposed a set of six basic states for recording how lots spend their time in the fab. We also discussed several subtleties regarding measurement of these states, and possible extensions for capturing more information. In this issue, we expand upon this topic by proposing a higher level metric derived from the WIP States, Overall WIP Effectiveness. We welcome your comments and feedback, as we attempt to develop useful metrics to provide a WIP-centered view of the fab.

This month we have a conference announcement and call for papers for the second ISMI (International SEMATECH Manufacturing Initiative) symposium on manufacturing effectiveness. This was a great conference last year, and we recommend that you participate if you can. We also have a new FabTime software tip of the month describing methods of copying chart images to other applications. In this month's subscriber discussion forum we have three responses to last month's main article on WIP States, one response to a previous article about WIP Utilization %, and a response to another subscriber's question about experiences in improving lot tracking for less-automated fabs.

A WIP-Centered View of the Fab: Part 1: WIP States (Issue 6.02)

In our main article this month we propose a set of basic states for recording how lots spend their time in the fab (we call them WIP States). These are analogous to the tool states defined in the SEM E10 standard, except that they apply to time spent by a lot, rather than time spent by a tool. We propose a set of six basic states, which encompass most of the time that a lot spends in the fab and discuss several subtleties and possible extensions. Next month we will expand on this topic by proposing a higher-level metric derived from the WIP States, Overall WIP Effectiveness. We welcome your comments and feedback, as we attempt to develop useful metrics to provide a WIP-centered view of the fab.

This month we have several community announcements, including notice of the formation of a new semiconductor manufacturing group called the Fab Owners Association (FOA). Our FabTime software user tip of the month is about viewing home page charts in slide show view. This issue

also brings subscriber discussion related to WIP utilization %, product mix, shift change effects, and improved lot tracking for less automated fabs.

Product Mix and Cycle Time (Issue 6.01)

In our main article this month we discuss the interaction between product mix and cycle time in a wafer fab. Specifically, we identify a number of reasons why increasing product mix may drive up cycle times. Although product mix itself is not a knob that people in the fab can just turn down to improve cycle time, we believe that exploring the underlying issues in more detail will suggest opportunities for cycle time improvement. We welcome your feedback.

This month's community announcements section consists of a call for papers that we thought some of you might find of interest. In our FabTime software tip of the month we describe the use of the Dynamic X-Factor chart for looking at shift change effects. This month we are in the rare situation of having no new subscriber discussion. We have listed the recent discussion topics, however, and invite your comments for future issues.

Management Behavior and Fab Cycle Time (Issue 5.10)

Because we have extensive subscriber discussion this month, our main article is relatively short. We turned for inspiration to the responses to our cycle time issues survey (in which we have been asking people "What is the biggest cycle time problem in your fab?"). We noticed a number of responses pointing towards management behaviors that influence variability in the fab, at least from the perspective of people working in the fab. We've chosen to highlight these responses and discuss their impact on our "Traffic Cop" cycle time management style recommendations.

In this issue we have an announcement about the latest version of the software, as well as a short recap of a recent industry conference. Our software user tip of the month concerns methods for updating home page chart data. In the subscriber discussion forum, we have several responses to last month's questions about paperless cleanrooms and the effect of linked tools on 300mm cycle times, as well as a new question about benchmarking for "single strand" toolsets.

Analyzing Capacity Using MES Data (Issue 5.09)

In our main article this month, we discuss using data from the fab manufacturing execution system (MES) to perform static capacity analysis. FabTime is in the business of taking data from the MES, and using it to provide information to the people who manage wafer fabs. Our software takes updates from the MES in near real-time, and stores the data in a separate database, making a digital dashboard of charts available via web browser. Recently, we have been working with our customers to use this data to help them plan capacity. The primary advantage of this approach is that most of the data is already available and automatically updated to reflect current fab conditions. This lets planners spend their time generating and running scenarios, rather than performing data entry to keep standalone capacity models up to date.

This month we have an announcement related to past issue abstracts (to make it easier for you to find references to topics previously discussed in the newsletter). Our software user tip of the month is about generating a list of hot lots. We also have subscriber discussion related to 300mm cycle times (in response to last month's issue) and paperless cleanrooms.

Real-Time Alerting based on Fab Conditions (Issue 5.08)

In our main article this month, we discuss real-time alerts sent to semiconductor wafer fab users to notify them of particular conditions in the fab. We review pros and cons of using these types of alerts at all, and then describe several examples in detail (including hot lot queue delay, early warning of lots due to reach time limit, and critical tool idle with WIP available). Finally, we solicit subscriber feedback on the general usefulness of alerts, and on other types of warning messages that might be useful in semiconductor fabs.

This month we have several announcements, as well as a considerable amount of subscriber discussion. Our FabTime user tip of the month describes how to add a chart from a shared home page tab to a user's own home page. Subscriber discussion topics include: capacity planning for time links between process steps, understanding 300 mm cycle time performance, assessing the impact of downtime on fab performance, setting targets for WIP and turns, and defining fab loading in the presence of multiple near-bottlenecks. We also have several responses to our question about the oldest continuously operating wafer fab.

Quantifying the Effect of Tool Downtime (Issue 5.07)

In our main article this month, we discuss metrics for measuring the effect of tool downtime. If we could eliminate downtime from our semiconductor wafer fabs, we could increase throughput (where the constraint tools have any downtime at all), and improve cycle time at the same time. In this article, we make a first pass at quantifying this impact more formally, by measuring the increased operation-level cycle time for lots that are in queue when a tool goes down. We believe that better understanding the cycle time cost from specific downtime events could be helpful for fabs in deciding where to focus tool improvement efforts.

This issue includes subscriber discussion related to capacity planning, Dynamic X-Factor, WIP Utilization, and metrics for measuring the effect of tool downtime. Our FabTime user tip of the month concerns setting a default time of day for newly generated interval-based charts.

Cycle Time Constrained Capacity (Issue 5.06)

In our main article this month, we discuss increasing semiconductor wafer fab throughput through improvements in cycle time constrained capacity. The idea is that fabs always have a buffer of planned idle time on tools, designed to keep cycle times from getting out of control. Through variability reduction, fabs can sometimes squeeze this buffer, without increasing cycle time. In an up market, this can lead to increased sales, from the same equipment set. The financial benefit from this can be substantial, and provides a clear justification for variability reduction / cycle time improvement efforts.

In this issue's subscriber discussion forum, we have discussion concerning several previously introduced topics: WIP Utilization Percentage, Dynamic X-Factor, and the Closest-to-Completion-Time Dispatch Rule. Our FabTime user tip of the month concerns setting filter defaults.

WIP Utilization Percentage (Issue 5.05)

In our main article this month, we propose a new wafer fab metric for tracking shift-level use of individual tools by operators, called WIP Utilization%. This metric was developed jointly by Frank

Chance of FabTime and Jimmy Martin of Analog Devices. We define WIP Utilization% as Productive Time / (Productive Time + Standby WIP Waiting Time). This is similar to our definition of Utilization, which is Productive Time / (Productive Time + Standby Time). However, in the denominator, we only include the standby time in which WIP is waiting for the tool. WIP Utilization% will approach 100% if, whenever WIP is waiting, and a qualified tool is available, the WIP is processed as soon as possible. Driving WIP utilization to 100% generally minimizes per-visit cycle times through the tool, and helps to maximize shift-level throughput. This metric overcomes several shortcomings of the standard utilization definition as a shift-level metric for operators in semiconductor wafer fabs.

In this issue's subscriber discussion forum, we have several responses to last month's subscriber discussion question, about breaking up standby time according to whether or not WIP is available. We also have a new subscriber discussion question about the closest-to-completion-time dispatch rule.

Presenting Fab Performance Data (Issue 5.04)

In our main article this month, we discuss ideas for presenting semiconductor wafer fab performance data. These ideas are based in part on concepts proposed by Edward Tufte, author of "The Visual Display of Quantitative Information". Tufte's suggestions include using quantitative metrics for data graphics and integrating text with graphical data in charts. We have included a detailed FabTime-generated example of improving an Excel-generated chart, and summarized a few recommendations from both FabTime and Edward Tufte. We hope that you find it interesting.

We have no new subscriber contributed discussion topics this month. However, we have included a sample of responses to our newsletter sign-up question: What is the biggest cycle time problem in your fab?" and we have posed a topic ourselves for future discussion.

Dynamic X-Factor Revisited (Issue 5.03)

In our main article this month, we revisit the topic of dynamic x-factor, a metric for semiconductor wafer fabs that we first described back in issue 4.08. Dynamic x-factor is a point estimate that looks at the total wafers that you have in your fab, divided by the wafers that are currently being processed on tools. In this article, we look further into what dynamic x-factor can tell us about how a fab is operating, with emphasis on evaluation of shift change coverage policies and comparison of relative performance across modules.

Community announcements in this issue include two calls for papers for conference sessions related to semiconductor manufacturing applications. Subscriber discussion topics include wafer holds, cycle time and yield, operator utilization, and dynamic x-factor.

Cycle Time and Yield Revisited (Issue 5.02)

Subscriber discussion topics for this month include nine responses to last month's topic of Cycle Time and Yield. These responses point out some significant omissions in our article. Therefore, instead of introducing a new main article, we've chosen to revisit the topic of cycle time and yield, and very briefly summarize the additional points made by contributing subscribers. This article is a companion article to Issue 5.01, and we recommend reading the two of them together.

Cycle Time and Yield (Issue 5.01)

This month's main article is about the interaction between cycle time and yield. We've always cited yield improvement as a potential benefit from cycle time improvement, and people we talk with about this generally agree. However, because the actual data tends to be proprietary in nature, references on this topic are scarce. Therefore, we've decided to open the topic for discussion here, and summarize a few references that are available. We hope that you'll find the discussion interesting.

Subscriber discussion topics for this month include responses to Issue 4.09 (WIPHours Metric) and Issue 4.11 (Cycle Time and Factory Size).

Cycle Time and Factory Size (Issue 4.11)

This month's main article is about the cycle time effect of changing factory size for semiconductor wafer fabs. Everyone knows that for a given fab, as start rates increase (as they seem to be doing for many fabs) cycle time is likely to also increase. What's less obvious is the behavior that one of our subscribers pointed out in this month's subscriber discussion forum: sometimes when start rates decrease, cycle time increases. This wouldn't normally happen if there were no other changes in the fab. Utilization would go down, for tools and operators, and cycle time would almost surely go down. However, that's not a realistic case. What really happens in many fabs is that when start rates go down, tools are turned off and staffing is reduced. The net result from this is that the bottleneck utilization of the fab may stay the same, or even increase. So, no cycle time payoff from the decreased start rate. What also happens is that the number of tools per tool group decreases, sometimes to the point of having one-of-a-kind tools in operation. This lack of tool redundancy is a key driver of cycle time (currently ranked third on FabTime's cycle time problems survey, after downtime and bottleneck utilization), and is the primary subject of this article.

Subscriber discussion topics for this month include two responses to last month's article about tool standby and productive time reporting. New topics include incorporating setup in equipment utilization calculations, understanding the cycle time effects of automated material handling and robotic systems, and understanding cycle time and "under-utilization" in fabs. This month also kicks off a new newsletter section: Cycle Time in the News.

Tool Standby and Productive Time Reporting (Issue 4.10)

This month's main article is about using manufacturing execution system (MES) data to calculate fab performance measures. More specifically, we discuss the cycle time management benefits of tracking standby and productive time, in addition to tracking tool downtime states. Tool utilization, defined as Productive Time / (Productive + Standby Time) is the largest driver of operation-level cycle times. For this reason, we recommend reporting tool utilizations on a short-term (e.g. shift-level) basis, and automatically flagging situations where utilization approaches 100%. Fabs may be able to do proactive things, like reassigning operators, or deferring engineering or maintenance time, to nip short-term cycle time problems in the bud. To do this, however, fabs will need to ensure that their manufacturing execution systems either track productive and standby state changes directly, or generates them in some other manner.

We have no subscriber discussion topics in this issue.

Identifying Temporary Bottlenecks in the Fab (Issue 4.09)

This month's main article is about metrics for identifying short-term bottlenecks in a semiconductor wafer fab. Last month we proposed the metric Dynamic X-Factor as a short-term indicator of overall fab performance. In this article, we focus more on tool-level performance metrics. The idea is to identify metrics that can be used at the start of the shift to highlight current or anticipated cycle time problems in the fab. We first discuss a few simple metrics, and their relative applicability to this problem. We then propose a simple calculation (WIP hours) for identifying short-term bottlenecks without performing simulation, by estimating the hours of work in queue for a toolset. We don't have all the answers here, but we would like to start a discussion with the FabTime newsletter community about this. Ultimately, we want to work towards developing useful short-term metrics for identifying temporary bottlenecks in wafer fabs.

Subscriber discussion topics for this month include two responses to last month's article about the performance metric Dynamic X-Factor, and new questions about managing in high-mix and R&D environments. We also have announcements about a new one-day version of FabTime's cycle time management course, a Cost of Ownership task force meeting, and the acquisition of WWK by its management team.

Dynamic X-Factor (Issue 4.08)

This month's main article is about the wafer fab performance metric Dynamic X-Factor. Dynamic X-Factor measures, on a point-in-time basis, how much of the WIP in the line is currently being worked on, instead of sitting in queue. If Dynamic X-Factor drifts upward, cycle time will probably start to increase in the future (because either there is more WIP, or WIP in the line is sitting more than it should be). Dynamic X-Factor is calculated by taking the total number of wafers in the fab and dividing by the number of non-rework wafers actually being processed. While Dynamic X-Factor works out to be the same as the regular cycle time X-Factor (cycle time / theoretical cycle time) on a long-term basis, Dynamic X-Factor is easier to calculate, and is more forward-looking than an X-Factor based on shipped lot cycle times. While there are some limitations to this metric, we think that it provides a useful indicator of current fab cycle time performance. We recommend its use for semiconductor fabs.

We have no subscriber discussion topics in this issue.

Identifying Real-Time Cycle Time Problems (Issue 4.07)

This month's main article is about identifying real-time cycle time problems in a wafer fab. We wrote this article in response to an informal survey that we have been conducting about cycle time problems in semiconductor wafer fabs. The fourth-most common response to date has been real-time identification of cycle time problems (e.g. problem tools or operations). This is a nuts-and-bolts kind of topic that we've addressed only indirectly in this newsletter so far. In this issue, we propose metrics and methods for identifying cycle time problems in the fab on a short-term basis, so that they can be addressed and improved. Metrics discussed include operation-level cycle time, summed operation cycle time, inventory age, arrival coefficient of variation, and availability variability. We also touch on some more detailed methods for using real-time data to understand problems and improve operational decisions. Specifically, we focus on tool dedication, staffing decisions, batch loading policies, and maintenance schedules.

Subscriber discussion topics for this month include a response to last month's main article about operators and cycle time, several responses to last month's question about how companies calculate On Time Delivery percentage, a new question about the productivity of engineering staff, and a new question about wet bench capacity.

In-Depth Guide to Operators and Cycle Time (Issue 4.06)

This month's main article is about planning and managing operators in semiconductor wafer fabs. In looking over the past issues of this newsletter, we observed that we have had a considerable amount of subscriber discussion related to staffing. This discussion has primarily fallen into two categories: 1) operator modeling/planning and 2) operator management (including dedication, cross-training, and performance evaluation). The first category concerns understanding how many operators will be required, and how they will impact cycle time and throughput. The second category concerns managing operators once staffing levels have been determined, to minimize cycle time and maximize throughput. In this article, we summarize the subscriber discussion to date on operators, bringing it into one place, instead of scattered across two years of newsletter issues. We will also summarize FabTime's thoughts on the operator-related questions and highlight industry resources that we know of related to operators (software, papers, etc.).

Arrival Variability and Cycle Time (Issue 4.05)

This month's main article is about arrival variability and cycle time in semiconductor wafer fabs. While working with our FabTime cycle time entitlement calculator (described in Volume 4, Number 3), we observed some interesting behavior for cases with a high degree of arrival variability. We found that arrival variability due to batching tended to have less of an impact on cycle time than other types of arrival variability for the cases that we investigated. In this article, we show examples generated from simulation models and discuss the impact of this behavior on the formulas in our operating curve generator and entitlement calculator. We also introduce a modification to our operating curve generator that accounts for arrival batching.

Cycle Time Effects of Equipment Downtime (Issue 4.04)

This month's main article is about the cycle time effect of equipment downtime. When we ask people what factors contribute to cycle time in their fabs, the number one response that we get is "downtime". Certainly, equipment downtime is a fact of life in wafer fabs. In this article we review the reasons why downtime has such a significant influence on cycle time (utilization and variability). We also propose three steps for mitigating the effect of downtime on cycle time.

Subscriber discussion topics for this month include material handling system metrics and cycle time reduction; the metric mean time to recover; and the cycle time effects of integrated metrology in the lithography area.

Cycle Time Entitlement (Issue 4.03)

This month's main article is about cycle time entitlement for semiconductor wafer fabs. This newsletter has frequently addressed topics related to managing and improving cycle times, and the various metrics for reviewing historical cycle times and benchmarking cycle time performance. But what people who work in fabs really need to know is: what is a good cycle time for our fab,

under our current constraints? And where should we focus our cycle time improvement efforts? Cycle time entitlement is FabTime's answer to these questions. More formally, cycle time entitlement is the best achievable cycle time for a fab given short-term realities related to tool utilization, staffing, and downtime characteristics. In this article we define cycle time entitlement, and discuss ways of estimating it, ways of using it, and associated data issues.

Subscriber discussion topics for this month include responses to our article about quantifying availability variability and to last month's subscriber question about train schedule batch policies, as well as a new question about estimating company-wide savings from cycle time reduction.

Quantifying Availability Variability (Issue 4.02)

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.

In this month's subscriber discussion forum, we have 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.

Quantifying Wafer Fab Variability (Issue 4.01)

Our main article this month is about quantifying variability in wafer fabs. We have talked many times about how wafer fab cycle time can be reduced by reducing fab variability. In this article, we describe a metric for quantifying this variability (coefficient of variation), and discuss how to calculate it for times between arrivals and for process times. We believe that by measuring variability, particularly relative levels of variability at individual tool groups and operations, readers will be better able to identify potential improvement areas.

In this month's subscriber discussion forum, we have responses from three subscribers to our recent topics regarding operator productivity.

Quality Moves: A Proposal for a New Performance Metric (Issue 3.10)

Our main article this month is about a new performance metric we are proposing. After discussing what attributes we believe should be found in metrics for daily production meetings, we propose Quality Moves. Quality Moves measure, on a shift basis, the best performance that can be achieved given the fab's WIP profile and resource availability.

In this month's subscriber discussion forum we have many responses to last month's main article about the impact of staffing (particularly operator delays) on cycle time. Most of the respondents agreed that operator delays do have an impact on fab cycle times, at least some of the time. We also have new topics raised by subscribers related to performing tool qualification on the bottleneck and estimating the impact of hand-carry lots on other lots.

The Impact of Staffing on Cycle Time (Issue 3.09)

We are interested in estimating the impact of staffing on cycle time. In this article, rather than tackle this issue in detail, we focused on one particular aspect - forced idle time on tools due to operator delays. To look at this visually, we built a very simple simulation model to study the issue. We found that even in models with only 3 tools, and light operator loading (50% busy), operator delays may increase cycle time significantly.

This month we also have subscriber discussion on capacity planning using simulation, as well as using fab-level metrics for understanding variability. We also present the results from last month's survey question about the number of certifications per operator that people have in their factories.

A Simple Rule of Thumb for Batching Decisions (Issue 3.08)

When a batch tool (e.g. diffusion furnace) is available and there are one or more lots ready to be processed, the operator must decide whether to start the batch immediately or wait for more lots. When a full batch of some recipe is available, the decision to start that batch is fairly easy. However, when less than a full batch of lots is available, the decision becomes more complex. On average, it is usually better for cycle time to start the batch immediately than to wait to form a full batch. However, despite this general rule, there are sometimes specific cases where it makes more sense to wait for the next lot before starting the batch. In this article, we propose a simple rule for deciding when to wait for the next lot, and when to just start the batch.

In this month's subscriber discussion forum, we have continuing discussion on recipe management, batch size decision rules, and operator cross-training.

FabTime Newsletter Retrospective (Issue 3.07)

In this month's main article, we have chosen to briefly review the topics described in the FabTime newsletter issues to date (both the main articles and the subscriber discussion topics). The primary reason for this is that we have many new subscribers, who may not be aware of the topics already covered. Even for long-time subscribers, job descriptions and market conditions change regularly. A topic that wasn't of interest to you when it first came out may be more relevant now.

In this month's Recommendations and Resources section, we review the many resources available on FabTime's website (papers, tutorials, book reviews, software demos, etc.).

Cycle Time Management Styles (Issue 3.06)

In this month's main article, we propose three distinct cycle time management styles, and describe how each can be used to improve cycle time. We have named these three styles: The Traffic Cop; The Shepherd; and The Relay Coach. These are management styles we have observed in real fabs, although the names and descriptions are our own. Each style is suited to a particular cycle time

focus. Traffic Cops control starts and WIP flow for production lots. Shepherds prevent engineering lots from disappearing onto shelves and hiding in corners. Relay Coaches ensure that critical hot lots are handed smoothly from one operation to the next. Graphical examples, using charts from FabTime's software, can be found on our website, at www.FabTime.com/ctmstyles.php

Discussion topics in this issue include: responses on wafer starts methodologies, treating scrap in product costing, and ramp planning; a reference to a conference presentation about operator modeling; a question about how much is too much in reference to operator cross-training; a question about how people handle recipe management; and a request for benchmarks for gallium arsenside fab cycle times.

The Bottom-Line Benefits of Cycle Time Management (Issue 3.05)

Our main article this month is about quantifying the bottom-line benefits of cycle time improvement. We discussed one particular benefit in a previous newsletter issue. In this new article, we provide a more comprehensive framework for linking cycle time management to financial returns. An Excel spreadsheet tool for what-if analysis is provided on FabTime's website (here). There's both money to be saved and additional revenue to be earned through cycle time improvement. Under the assumptions in our default example, the total annual benefit of cycle time improvement could be more than half a million dollars.

Discussion topics in this issue include: a request for information on wafer start methodologies; a request for research on staffing models; a request for literature on ramp models; a question about how companies treat cost of scrap; and a question about calculating mean time between assists.

Cycle Time and the Core Conflict (Issue 3.04)

This month's main article, Cycle Time and the Core Conflict, is a guest article, written by Dan Siems, of Philips. Dan was recently appointed World Wide Wafer Fab Cycle Time Manager for Philips Semiconductors. This article represents Dan's thoughts on a core conflict that often exists in managing wafer fabs - trying to get lots out quickly, but having to frequently stop the lots for quality checks. Dan proposes the elements that he believes must exist to weaken this conflict, and maintain good cycle times over the long term.

This month in the subscriber discussion forum we have several responses to last month's main topic of equipment dedication. Other topics discussed in this issue include lot size change, foundry performance data, and the interaction of AMHS control and dispatching.

How Much Does Tool Dedication Inflate Cycle Time? (Issue 3.03)

We talked back in Issue 1.8 about the fact that single path tools tend to drive up cycle times. The question is, how much does tool dedication inflate cycle times? The are sometimes important reasons to have dedicated tools. What's needed is a way to explore trade-offs. In this article, we present an approximation for queue time as a function of number of machines in a tool group. This approximation clearly shows that queue time decreases as the number of tools in the group increases (for the same total traffic intensity of the tool group).

Discussion topics in this issue include: a question about segregating downtime and idle time into "good" and "bad" for PEE calculations; a request for opinions on how to model single wafer lots; a question about the details of generating characteristic curves; a request for foundry performance data benchmarks; and several detailed responses to the Volume 3, Number 2 hot lot article.

Cycle Time and Hot Lots (Issue 3.02)

The article is drawn from a presentation that Frank Chance made at Arizona State in January. We present a formula for estimating the average cycle time of lots through a tool that processes lots with different priorities (regular lots and hot lots). We provide a numerical example that shows how the cycle time of the regular lots increases as the percentage of hot lots is increased, and discuss implications for managing hot lots in a wafer fab. An example can be seen here.

Discussion topics in this issue include: a response to the question about performance measures regarding human resource to activity relationships; a request for cycle time reduction case studies; and an observation on production equipment efficiency (PEE) as a measure of tool variability.

OEE and Cycle Time (Issue 3.01)

In a wafer fab, cycle time tends to increase with increasing equipment loading (with some exceptions for batch tools). In large part to combat high cycle times, fabs typically plan for some amount of idle time on most tool groups. OEE, in its traditional definition, is contradictory to such planned idle time, since all standby time (including planned idle time) drives down OEE values. This puts fab personnel in a tight spot when they are pushed to simultaneously increase OEE values and decrease cycle times. Production Equipment Efficiency (PEE) is a related metric that calculates equipment productivity only during the time that product is available at the tool. Improving PEE, therefore, is not in conflict with reducing cycle times. PEE only penalizes tools for standby time during which lots are waiting (e.g. time when WIP is present, but there is no operator to load the tool). For bottlenecks, there will likely be very little time during which no WIP is waiting. Therefore, for bottlenecks, PEE and OEE will yield similar values. For non-constraint tools, however, PEE values will usually be higher than OEE values. The important thing is that increasing PEE values will not conflict with reducing cycle times. For fabs trying to improve or maintain cycle times, using PEE instead of OEE may be more effective, at least for non-constraint tools.

Discussion topics in this issue include: a request for information on measuring shift performance; a question about performance measures regarding human resource to activity relationships; and a question about model accuracy relative to actual performance.

Explicitly Including Cycle Time in Capacity Planning (Issue 2.10)

Our article this month is a continuation of last month's discussion on including cycle time in the capacity planning process. Last month we talked about how people do this implicitly, though the use of capacity loading factors. This month, we talk about a more explicit method of including cycle time in the capacity planning process, through the use of simulation models. This article is based on a project that we did for Seagate Technology several years ago. The method involves using simulation to estimate the cycle time of candidate models, and adding tools on the basis of greatest cycle time reduction per dollar of fixed cost. The main point from this study is that other

factors besides equipment loading have an influence on the cycle time contribution of individual tool groups. Considering those other factors can allow you to plan for more cost-effective toolsets. Navi Grewal, one of the original authors, collaborated with us on this article.

Discussion topics in this issue include: several responses to the 300mm lot size question; a proposal for calculating the cost of cycle time; a statement of the continued need for moves as a daily fab performance metric; a modification to the cycle time calculations in the characteristic curve generator; a case study comparing actual performance to short-term goals; and questions about the implications of 300mm factory size, relating OEE to cost per wafer, modeling operator impact, modeling cycle time and WIP during a volume ramp, the industry definition of "loading", calculation of product and factory line yield values, and benchmarking cycle time for wafer production.

Implicitly Including Cycle Time in Capacity Planning (Issue 2.09)

Cycle time is always considered in the capacity planning process for wafer fabs. In most cases, however, cycle time is considered implicitly, rather than explicitly. If your capacity planning team was not considering cycle time, they would plan for the minimum toolset to meet throughput requirements, with perhaps some additional tools to account for potential product mix changes. Instead, they include planned idle time for essentially all tool groups. They also try to avoid one-of-a-kind tools, frequently recommending duplicates of even very lightly loaded tools. In this article, we will talk about these traditional methods of implicitly accounting for cycle time in the capacity planning process. Next month we will look at ways to be more explicit, and shoot for specific cycle time targets.

Discussion topics in this issue include: a question about the standard for 300mm lot size; a question about quantifying cost savings from cycle time reduction; an inquiry about the availability of published productivity report indices for fabs; a request for references on literature regarding new product introductions; and a practical best-case X-factor for cycle time goals taking human performance into account.

Setting Goals for Fab Performance (Issue 2.08)

We are surrounded by performance measures. Goals help us to convert these absolute numbers into relative “good or bad” indicators. At higher levels of an organization, you deal with aggregated goals. More detailed goals must be set, however, at lower levels of the organization. These detailed goals must be consistent with the higher-level goals, and must be useful for day-to-day operations. The closer you look at the process, the more you see the proliferation of goals. If you can address this proliferation, you can generate appropriate goals for a wide variety of intermediate performance measures. It’s important to remember the implicit assumptions behind long-term goals, however, and to mix long-term goals with appropriate short-term targets.

Discussion topics in this issue include: a question about generating operating curves for the wafer test area; a description of experiences in measuring process time variability; and a request for the logic behind the variability parameters in the FabTime characteristic curve generator.

Cycle Time Characteristic Curve Generator (Issue 2.07)

The FabTime Cycle Time Characteristic Curve Generator is an Excel-based tool for exploring cycle time and utilization trade-offs for single tools with failures. You can enter parameters for process time, mean time between failures, downtime percentage, and system coefficients of variation for up to three scenarios. The calculator then displays characteristic curves for the scenarios, allowing you to get a quick visual impression of the impact of both downtime and variability attributes. The curves are based on a queueing approximation that we received several years ago from Ottmar Gihr of IBM Germany. You can download the characteristic curve generator from FabTime's website (here).

Discussion topics in this issue include: the method for ordering the SEMI E-79 Standard document; a description of where to find abstracts to INFORMS articles; a request for fab cycle time benchmark data; and a request for tool cycle time benchmark data.

What is One Day of Cycle Time Reduction Worth? (Issue 2.06)

The article was written by Frank Chance, with assistance from Stuart Carr (consultant and FabTime affiliate), and Ken Beller. Frank started thinking about this question because, as President of a cycle time management software company, he is frequently asked about the dollar benefit of cycle time reduction. This article outlines several potential ways to quantify this benefit, and focuses in particular on the timely issue of inventory write-off during an industry downturn. The article references an Excel-based cycle time payback calculator that was formerly available from FabTime's website. The calculator has since been replaced by a more comprehensive calculator described in Issue 3.5.

Discussion topics in this issue include: the SEMI E-79 Standard definition of ideal process time; and a clarification of the OEE calculations for quality rate.

One-Year Anniversary Issue (Issue 2.05)

This issue contains the abstracts to all previous issues. It also contains additional discussion on OEE, and several industry announcements.

In-Depth Guide to OEE Resources (Issue 2.04)

Most of our readers are familiar with the general concept of Overall Equipment Efficiency (OEE). OEE is a tool-level measure reflecting how much good product the tool produced relative to some theoretical amount that it could have produced. Typical OEE values in a wafer fab are less than 50%. Given the high cost of equipment, there is a clear incentive to make OEEs as high as possible. OEE is the measurement that's used in TPM (Total Productive Maintenance), a methodology for improving the entire manufacturing process.

In this article, we review the formulas for calculating OEE (both the full formula and a short-cut version), as well as some of the reasons for low OEE in wafer fabs. We also include a series of links to OEE resources on the Internet (including primary resources from SEMI and SEMATECH), as well as some additional published OEE references.

The power of OEE is that it provides a clearly defined metric by which equipment performance improvement projects can be measured. SEMI and SEMATECH have gone to great lengths to define OEE, and also the necessary supporting metrics like the SEMI E-10 equipment states. The nice thing about this is that it means that you can compare OEE values across factories, and even across companies, and get a true picture of your factory's performance. Another nice thing about OEE is that it drives you to do good things, like reduce setup and rework and scrap and starvations due to WIP or operator shortages. By focusing on the six types of losses highlighted by OEE, you can design a strong equipment improvement program, and monitor your progress through trends in the overall metric.

Improving Cycle Time During a Downturn (Issue 2.03)

Downturns are a fact of life in the cyclic semiconductor industry. Various factors contribute to their existence - capacity buildup (and the long lead-time required in capacity purchases), decline in selling prices, inventory build-up, and the general state of the economy. This one seems to have been triggered mainly by the last two factors, but explanations and predictions also seem to change every day.

The quickest way to reduce cycle time in a wafer fab is to significantly decrease start rates. This moves your factory to the left on the cycle time vs. factory loading curve, to a region of lower cycle times. The irony is that just when customers aren't clamoring for product, your fab can delivery product with record cycle time and on-time-delivery performance. It's very easy under these conditions to get a bit sloppy, and to take the lower cycle times for granted. But then when start rates begin to increase, when customers are paying attention again, your cycle times will degrade rapidly. If you don't have great cycle times now, you certainly won't have great cycle times when start rates go back up. Therefore, we suggest using this time to focus on low cost cycle time improvement efforts, including setup/dedication policy investigation, process analysis, layout analysis, bottleneck analysis, OEE/TPM analysis, simulation model validation, system upgrades, and education.

A downturn is a tough time - stressful, hard on your stock portfolio, and filled with the specter of layoffs. But it does offer at least one potential benefit: time to think. Time to think about manufacturing issues like lot size and batch size policies. Time to think about tool dedication schemes, and layout changes. Time to get your fab in order, and drive your cycle times to a minimum, before the next upturn comes along.

Discussion topics in this issue include: a success story on cycle time reduction through batch size decision rule changes; and a clarification of the units in the P-K formula.

Should You Reduce Lot Sizes to Reduce Cycle Times? (Issue 2.02)

This article concerns possible changes to production lot sizes for cycle time improvement. For fabs running 50 wafer lots, changing to 24 or 25 wafer lots offers a potential cycle time reduction opportunity. However, there can be tremendous resistance to this idea, and there are a number of potential pitfalls. In this article, we first review the reasons for the cycle time reduction opportunity, and then discuss some of the pitfalls.

The justification of lot size reduction for cycle time reduction comes into play primarily due to time savings at per-wafer tools, which can include critical tools such as steppers and implanters. In addition to providing these direct cycle time benefits, smaller lot sizes also make a fab more flexible, more adaptive in the event of problems, and can reduce variability. However, there are a number of issues to consider before changing the lot size, any one of which might keep a lot size reduction from being worthwhile, or even render it detrimental. These include capacity, material handling, MES, and dispatching/complexity issues, and are discussed in detail in the full article.

We have no black-and-white recommendation to make concerning lot sizes and cycle time. Smaller lot sizes may reduce cycle time, and make a fab more flexible. However, reducing the lot size can cause problems with material handling, capacity, MES performance, and fab complexity, particularly during the transition period. We suggest then, that you consider lot size reduction to reduce cycle times, but that you consider it very carefully.

Discussion topics in this issue include: observations about time constraints and batch size decisions, and sequence dependent setups and batch size decisions; and a question about defining utilization at batch tools.

Impact of Batch Size Decision Rules on Cycle Time (Issue 2.01)

Batch tools are tools in which more than one lot may be processed at one time. They are generally used for very long operations, such as furnace bake operations. Processing time is usually independent of the number of lots in a batch, and once a batch process begins, it cannot be interrupted to allow other lots to join. From a local perspective, when a furnace is available and full loads are waiting, the decision to process a batch is obvious, since no advantage can be gained at that work area by waiting (although a decision may still be needed concerning which product type to process). However, when there is a furnace available and only partial loads of products are waiting, a decision must be made to either start a (partial) batch or wait for more products to arrive.

There are two problems with running a partial batch. One is that the unused capacity of the furnace will be "wasted." The other problem is that lots that arrive immediately after the batch starts cannot be added to the batch, and might have to wait many hours until another furnace is available. There are also problems that stem from waiting to form a full batch. The lots that are waiting to be processed incur extra queue time while waiting for other lots to arrive. The furnace is held idle, driving down its efficiency. And full batches contribute more to variability after the furnace operation.

This article discusses policies for deciding when to form a partial batch, using simple numerical examples and simulation results. We conclude that for batch tools that are not highly loaded, forcing full or near-full batches can significantly increase local cycle times, as well as overall fab cycle times.

Understanding the Impact of Single-Path Tools (Issue 1.08)

Single-path tools are a common feature in wafer fabs. They occur whenever a single tool is the only piece of equipment qualified to process a particular operation. During fab startup, the majority of equipment will be single-path (since only one tool of each type has been purchased).

As fab volume grows, and duplicate tools are brought on-line, the number of single-path tools is usually reduced. At this point, however, there is often a choice in how the duplicate tools are configured -- cross-qualified in some fashion, or dedicated to individual operations.

In this article, we examine the impact of this tool-dedication decision on the number of single-path tools, and ultimately on cycle time, using concrete numerical examples and simple queueing approximations. Based on our analysis, the sample 100% dedicated-tool configuration results in an average cycle time that is nearly twice as long as the fully cross-qualified configuration. We also include a more intuitive explanation of the advantages of cross-qualification, based on other real-life examples.

While there are certainly other factors affecting the cross-qualification decision, our results suggest that if you do have a legitimate choice between cross-qualification and tool-dedication, you should consider the cycle time benefits of cross-qualification when making your decision.

Discussion topics in this issue include a proposal for cycle time reduction through tool integration and a suggestion about using Production OEE.

Improving Factory Cycle Time Through Changes at Non-Bottleneck Tools (Issue 1.07)

If you want to improve throughput for your fab, you need to start with the bottleneck (or bottlenecks), and work from there. However, this is not necessarily true when you're trying to reduce cycle time. We believe that you can reduce overall cycle time by reducing cycle time at any tool group in the factory.

The notion that you can improve overall cycle times by reducing cycle time at the bottleneck is obvious. And in fact, the bottleneck is a good place to start cycle time improvement efforts, since you probably have a large queue there, and lots of waiting time. The purpose of this article is to point out that you can ALSO reduce cycle time by making changes at non-bottleneck tools. This is far less obvious. With throughput, it doesn't matter if you process at a higher rate at non-bottleneck tools, because things get held up at the bottleneck anyway. Sometimes this happens with cycle time, too. But not always. We divide our discussion into three cases: tools located after the bottleneck in the process flow, tools located before the bottleneck, and tools located between visits to the bottleneck. We also include a series of concrete, low-cost suggestions for improving cycle time at non-bottleneck tools.

Our overall point is very simple: actions that you take to improve cycle time at non-bottleneck tools often improve overall product cycle times. For operations located before the first visit to the bottleneck, or after the last visit to the bottleneck, the cycle time reduction leads to an essentially direct reduction in the overall cycle time. For intermediate operations the situation is less clear, but we believe that improvements here can sometimes improve cycle time dramatically, and in the worst case, will not make cycle time any worse. If you focus your efforts strictly on bottleneck tools, then, you miss out on many opportunities for improvement.

Discussion topics in this issue include: a question about tool performance vs. rate of return.

Performance Measures Typically Used in Wafer Fabs (Issue 1.06)

Wafer fabs cost a lot of money. Fab managers, therefore, are constantly under pressure to run them well, so that the huge investment in capital equipment is not wasted. But what does it mean to run a wafer fab "well"? In an ideal world, we would be able to keep all of that expensive equipment highly utilized, with the utilization dedicated completely to productive work. At the same time, we would have low and predictable cycle times, and a minimal amount of capital tied up in WIP. We would keep our operators busy and effective all of the time, so that we weren't wasting salary on having people stand around the fab. We would constantly improve our products, yet always maintain 100% line yield. We would keep costs down, but be able to charge high prices by having speedy time to market.

Of course this combination of circumstances is impossible for many reasons. A wafer fab, as we discussed in the early issues of this newsletter, is a highly variable environment. In the presence of variability, high utilizations lead inevitably to high cycle time and WIP. You can load your operators and your tools heavily, or you can have low cycle time and WIP. You can't do both, unless you stamp out variability.

So the question is, what performance metrics should a fab manager use to make sure things are on track? And after deciding which to use, what are the correct definitions to use for these metric? We have observed, during our years of consulting, that different people often define the same metric differently. This is a source of confusion when comparing performance between or within companies. When people talk about utilization, for example, there are several things that they might mean. Similarly for turns. We therefore are proposing some definitions to apply within our niche of cycle time management. The terms defined in this article include starts, utilization, OEE, turns, throughput, line yield, cycle time, cycle time/raw process time, and cycle time per layer. We discuss each of these in detail.

Theory of Constraints and Just-in-Time Manufacturing (Issue 1.05)

This article is concerned with an apparent conflict between an implication of the Theory of Constraints (TOC) as applied to wafer fabs and the application of just-in-time manufacturing (JIT). One implication of TOC is that utilization of manufacturing resources should be intentionally unbalanced. The result is an identifiable bottleneck that is managed to optimize the throughput-accounting performance measures (throughput dollars, operating expense, and inventory dollars).

Just-in-time manufacturing refers to the mindset spearheaded by Taiichi Ohno at Toyota Motor Company. In an effort that dates to the 1940's, the company developed and implemented a number of improvement techniques aimed at two basic goals:

1. Just-in-time delivery of material precisely when it is needed.
2. Autonomation, or machines that are both automated and fool-proofed.

JIT manufacturing techniques include setup reduction, total quality management, and kanbans. Kanbans in particular have developed a strong association with just-in-time manufacturing, which can cause considerable confusion, since kanbans require a more balanced line.

FabTime asks: Do the manufacturing recommendations of the theory of constraints (an unbalanced line being one of these) conflict with just-in-time manufacturing? We then reconcile Jonah's quote with Toyota's success by recognizing that both the theory of constraints and just-in-time manufacturing use WIP-limiting techniques - the difference lies in the extent to which these techniques are applied throughout the factory.

We conclude that if you are going to adopt a just-in-time manufacturing mindset, or a goal manufacturing mindset, you should set aside sufficient time to apply the entire process. Saving time by skipping to the answers (e.g. using existing implementation techniques such as kanbans or drum-buffer-rope) will likely result in little long-term gain.

A Short Introduction to the Theory of Constraints (Issue 1.04)

The Theory of Constraints is now in its fourth decade of development. In order to install any scheduling system into a complex job-shop environment (like a wafer fab), Eli Goldratt discovered that it may be necessary to first solve much deeper basic problems. It is this insight that led Goldratt to the concepts found in "The Goal", first published in 1984. Most people are introduced to the theory of constraints via "The Goal", often at the urging of a friend or colleague who has previously read it. The book is a fast-moving novel that considers the plight of Alex Rogo, a plant manager whose factory is in deep trouble.

The book outlines Alex's development (through the help of his mentor, Jonah) of a series of performance measures that, if improved, will result in the factory meeting its goal. To improve these performance measures requires a sequential process of identifying the bottleneck, improving the bottleneck's performance, and then identifying the next bottleneck. Eventually, Alex's team learns that not all bottlenecks are physical tools in the factory, and that policy constraints can cause bottlenecks too. The book concludes with a systematic method for identifying and attacking system constraints (this is the theory of constraints, or TOC). FabTime's write-up on the subject concludes with some implications of TOC for wafer fabs.

Reducing Variability in Observed Process Times (Issue 1.03)

Little's Law: The relationship between cycle time, WIP, and throughput

The relationship between cycle time and WIP was first documented in 1961 by J. D. C. Little. Little's Law states that at a given throughput level, the ratio of WIP to cycle time equals throughput, as shown in the formulas below:

Throughput = WIP / Cycle Time Cycle Time = WIP / Throughput

In other words, for a factory with constant throughput, WIP and cycle time are proportional. Keep in mind that Little's Law doesn't say that WIP and cycle time are independent of start rate. Little's Law just says if you have two of these three numbers, you should be able to solve for the remaining one. The tricky part is that cycle time and WIP are really functions of the start rate. So changing the start rate in fact changes all three parameters, but Little's Law should hold for the new numbers. Discussion topics in this issue include: reducing variability in observed process times.

The P-K Formula (Issue 1.02)

The Pollaczek-Khintchine (called P-K, for obvious reasons) formula gives the expected average WIP at a single-tool workstation where arrivals to the workstation are highly variable, and process times are somewhat less variable. More specifically, the formula applies when interarrival times to the workstation are exponentially distributed, and process times follow a general distribution (what is known as an M/G/1 queue). For tools that fit this description, the expected WIP can be easily computed from the mean interarrival time, the mean process time, and the variance of the process time distribution.

The P-K formula tells us that, if we look at individual tools in the fab, anything that we can do to reduce variability in the process times seen by successive lots will directly act to reduce WIP at these tools, without requiring a reduction in tool loading. And, as will be discussed in the next issue of the newsletter, cycle time will go down at the same time. The P-K formula is the mathematical justification for variability reduction efforts in a wafer fab. Discussion topics in this issue include: contributors to wafer fab variability.

The Hawthorne Effect (Issue 1.01)

The Hawthorne Effect is named after a series of studies conducted at the Western Electric Hawthorne plant 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, the researchers concluded that productivity increases as a result of attention received by the workers. 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 (Hopp and Spearman, Factory Physics, 1996). This month's subscriber discussion forum focuses on knowledge-sharing regarding lot release, dispatch, and scheduling techniques for cycle-time management.