FabTime Cycle Time Management Newsletter

Volume 15, No. 3 **May 2014**

Information

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

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. New features in the latest version include Starts Stacked Trend and Pareto Charts, and Shipments Stacked Trend and Pareto Charts.

Editor: Jennifer Robinson

Keywords: Lot Size; Forecast Arrivals; Fab Management; Data Management

Table of Contents

Welcome

Welcome to Volume 15, Number 3 of the FabTime Cycle Time Management Newsletter! We hope that spring finds you all well. 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. We welcome your feedback.

Thanks for reading – Jennifer

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Community News/Announcements

FabTime Patch 105 Released

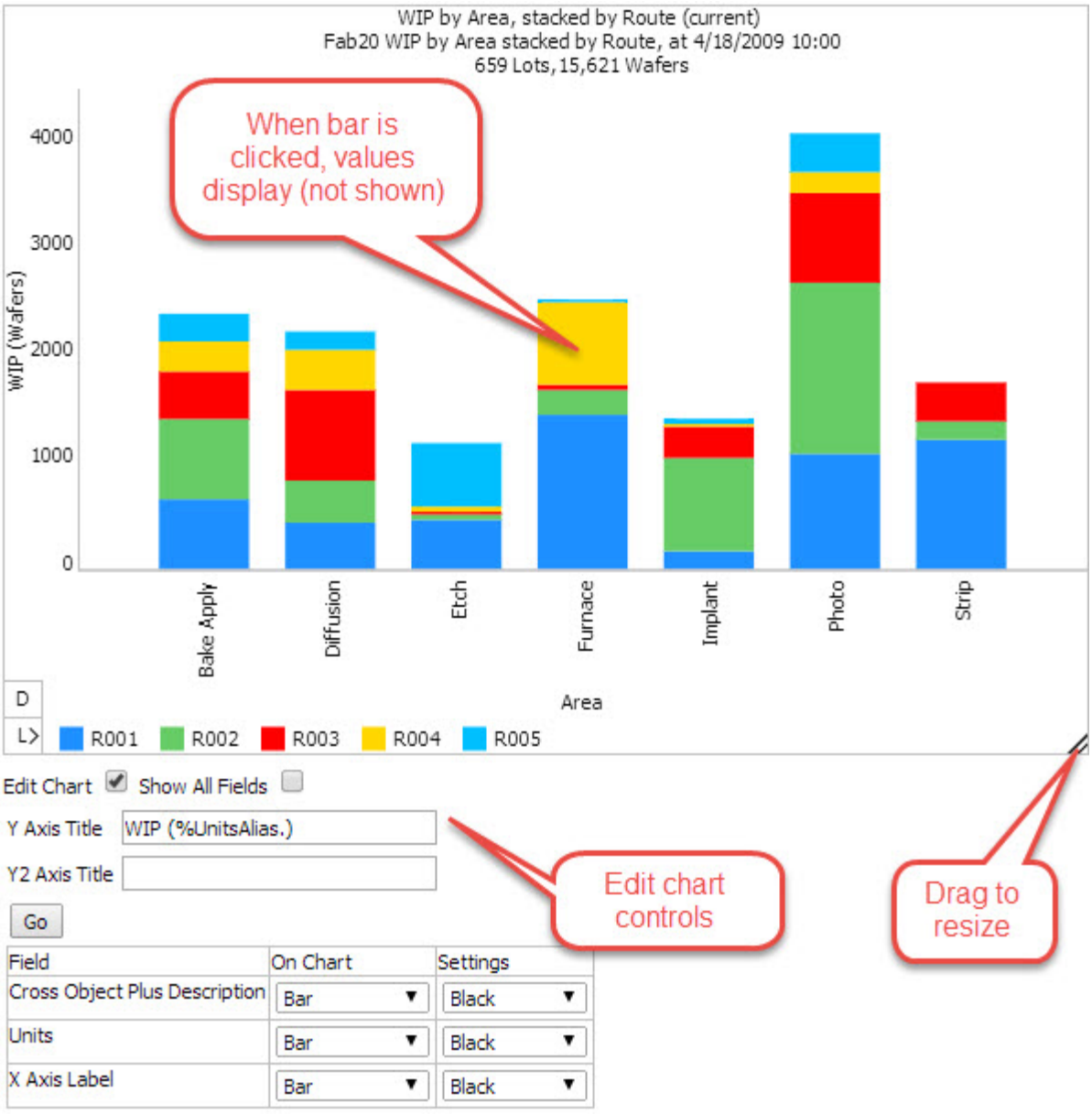
May 2, 2014 -- FabTime is pleased to announce the release of Patch 105 of our web-based dashboard software. Highlights in this much-anticipated release include:

■ **JavaScript Charts**. The JavaScript charts are dynamic, allowing features such as inline legends (on the chart bars), click to view pop-up data values directly on the chart, and drag-to-resize. See below.

■ **Edit Chart capability** for single-page charts. With the "Edit Chart" control, you can:

1. Remove a series from the chart (e.g. remove WIP line from moves trend chart).
2. Control series type (bar, line, etc.) and series color.
3. Add arbitrary series from data table to chart (e.g. change the moves lot list to display actual and theoretical UPH for each move, rather than cycle time for each move).

■ New **Starts Stacked Trend**, **Starts Stacked Pareto**, **Shipment Stacked Trend**, and **Shipment Stacked Pareto** charts.



- **Aggregating of data table rows** for the same x-axis value in all cross-tab charts (stacked charts).

- **New Earned Plan Hours Trend/Pareto charts** that show raw earned plan hours, not normalized by WIP

- **OEE chart enhancements**
  1. WIP filters on OEE charts
  2. More flexibility in Performance Efficiency calculations for multi-chamber tools

- Support for **site-configurable subtraction filters** on Cycle Time charts (instead of being limited to subtract owner, hold code, and operation

- Support for blocks of **time-constrained process steps** in dispatching, as well as enhanced support for current step batch efficiency.

- **Speed optimization** for various charts and goal transactions.

Please contact your site's FabTime administrator for details on when this new release will be available on your production server.

Call for Papers: The 2014 International Symposium on Semiconductor Manufacturing Intelligence (ISMI)

The 2014 International Symposium on Semiconductor Manufacturing Intelligence will be held August 16th - 18th, 2014, in Taipei, Taiwan. ISMI2014 aims to provide a platform to foster the exchange of research developments and latest practice on automation science & engineering, operations research, evolutionary algorithms, data mining, manufacturing informatics, and decision analysis for semiconductor manufacturing intelligence to enhance collaborations to address critical research and industrial issues.

Topics of Interest Include:

- Manufacturing Intelligence
- Big Data & Data Mining
- Manufacturing Strategy
- Manufacturing Informatics
- Automation
- Semiconductor Ecosystem
- Equipment Real-time Decision
- Advanced Process Control
- 450mm Wafer Migration
- Modeling & Decision Analysis
- Evolutionary Algorithms
- Green Supply Chain
- Corporate Resource Planning & ERP
- AMHS Routing & Scheduling
- Manufacturing Innovation
- e-Manufacturing
- Simulation Optimization

Paper submission:

Extended abstract including main ideas and contributions and/or full manuscript not exceeding 6 pages in IEEE format should be submitted through the EasyChair conference system before June 30, 2014, while camera ready manuscript should be submitted before July 31, 2014. Details can be found here, or consult program committee, Professor Jei-Zheng Wu.

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

FabTime User Tip of the Month

Predict which Lots Will Ship this Week and View Expected On-Time Performance

Do you need to know which lots can be expected to ship from the fab this week, given their current location and planned cycle time for remaining steps? You can use the Forecast Outs Lot List chart. Simply:

1. Press "Show" next to "Forecast Charts" on the Charts page.

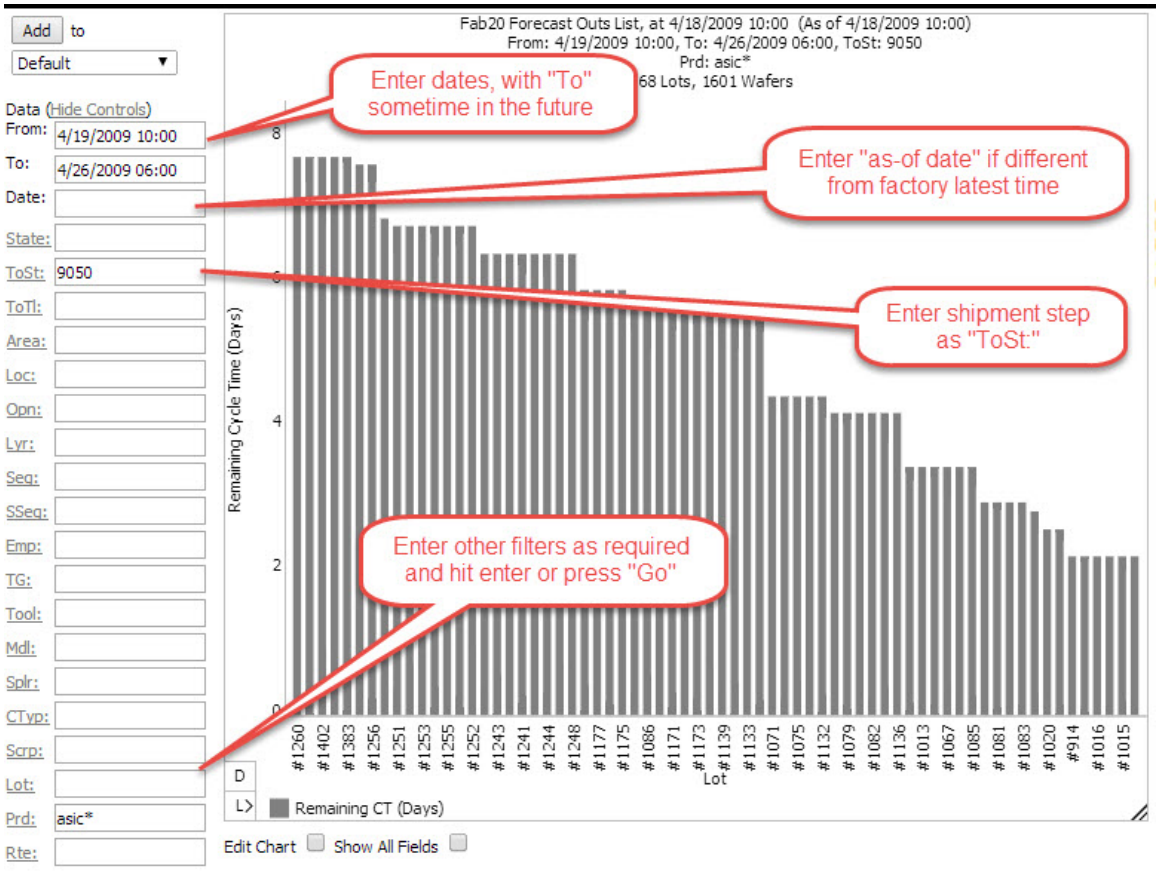
2. Press "Go" next to "Forecast Outs Lot List".

3. Change the "From" date to the current date and time, and the "To" date to the end of the week (or as required). You may also enter an "as-of time" for the forecast calculations in the "Date" field. If you do not specify an as-of time (Date:), FabTime uses the latest time for the factory.

4. Enter the Step ID for the last operation in the process flow (or the operation that you use to designate shipment) in the "ToSt:" filter. Click on "ToSt:" if needed to see the list of steps that can be included, or start typing and use FabTime's autocomplete function.

5. If necessary, enter Owner, Product, or other filters (if you are looking at some subset of the shipments).

6. Press enter (or click the "Go" button beneath the primary set of filters. The resulting Forecast Outs List chart shows the list of all lots expected to complete the designated "ToSt" operation during the specified time period (based on planned cycle time data included in your FabTime database). The height of each bar shows the remaining expected cycle time until the lot ships. See an example below.

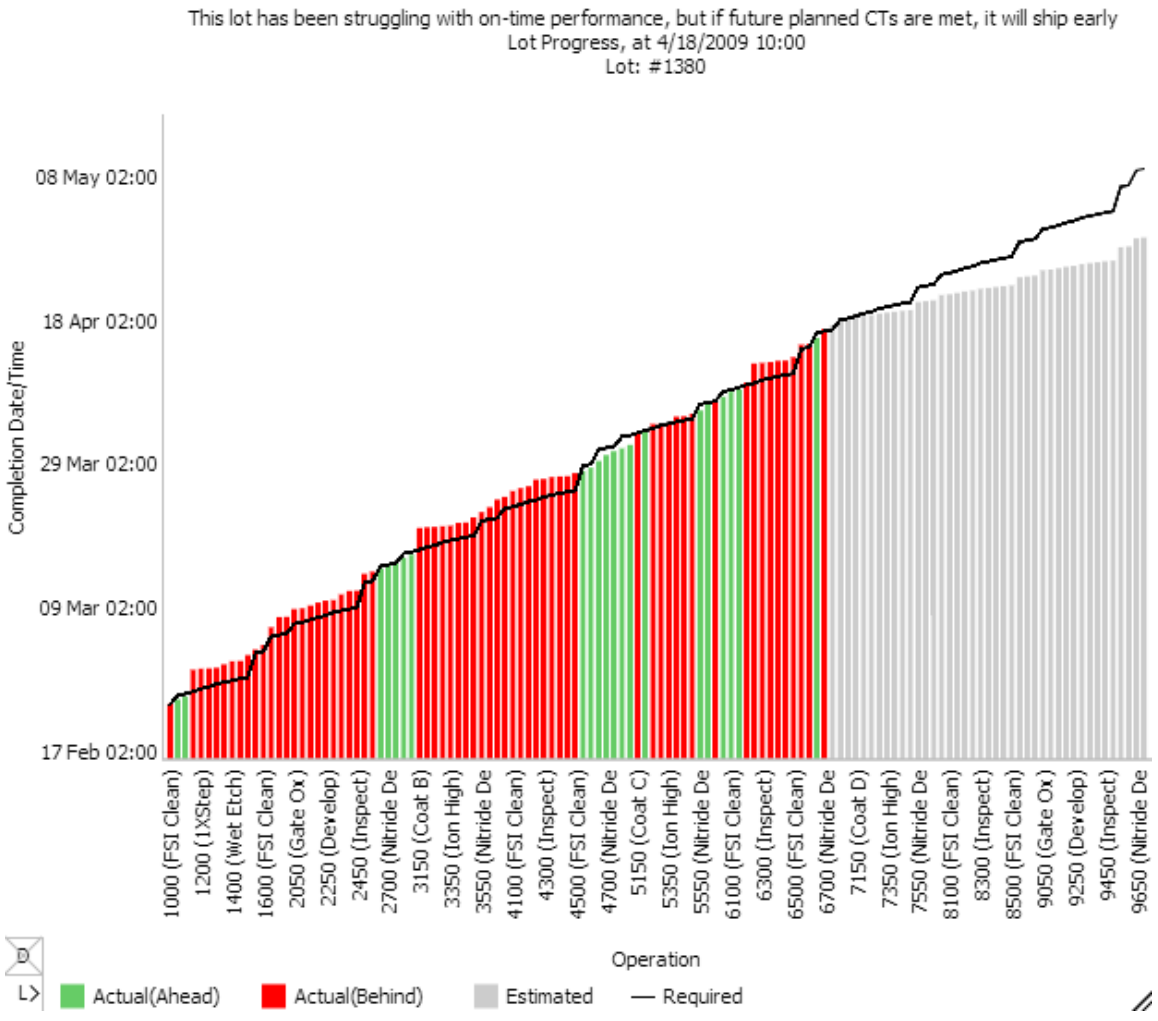


7. In the data table, compare the "Forecast Out" and "Factory Due Date" columns to see which lots are expected to ship ahead of (or behind) their due dates. You can export the data table to Excel to view this data in more detail and perform calculations. Be sure to select "Excel(All Rows)" to include all lots.

8. Alternatively, for any individual lot, click on the "Progress" link to view the projected shipment date vs. due date graphically. The far right column of the data table indicates whether the lot will be ahead of or behind schedule at shipment.

The figure below shows an example of a Lot Progress chart. This lot has struggled with on-time performance up to this point. However, if planned cycle time targets are met for future operations, the lot will ship early. Of course, the data in this chart will only be as accurate as your planned cycle time data by step. This is static data, and is not able to consider down tools, etc. The Lot Progress Chart does allow you to do limited what-if analysis on changing the x-factor used in calculating the planned cycle time for future steps. However, this is currently only available on an individual lot basis. Please do let us know if there are changes that would make these charts more useful for you.

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



Subscriber Discussion Forum

Issue 15.02: Lot Size Change

An anonymous subscriber wrote: "I read your recent newsletter with interest – what caught my eye in particular was the "Impacts of Changing a Fab's Lot Size" article, because I have co-authored several similar papers in the past with various colleagues, but I wanted to let you know that there were some points made in the article that did not sit well with me, as described below.

1. **Per-Wafer Tools:** the article states: "The wafers in a lot are processed one at a time through a single operation, and then the lot is sent on to the next operation. Examples of per-wafer tools include steppers and implanters."

Implanters typically process multiple wafers at a time and should not be classed as "Per-Wafer Tools".

FabTime Response: Interesting. We suppose that another classification may be needed here, because these don't fit into the other tool categories, either. For practical purposes in the lot size change discussion, Implanters are closest to Per-Wafer Tools. Multiple wafers may be processed at one time, but wafers also spend time waiting for the other wafers in a lot to be completed. So, smaller lot sizes do lead to cycle time improvements through Implanters, which is the primary point. Thank you for your clarification.

2. **Per-Lot Tools**: the article states: "The entire lot can be processed at one time. Examples of per-lot tools include sinks and inspection tools such as CD-SEMs."

CD-SEMs process wafers one at a time, and should therefore be classed as "Per-Wafer Tools" and not as "Per-Lot Tools".

FabTime Response: OK, thanks for that clarification.

3. **Per-Batch Tools:** the article states: "The number of wafers that can be processed at one time is different from the number of wafers in a lot…"

Per-Batch Tools typically process whole lots; therefore the number of wafers that can be processed at one time is the same as the number of wafers in a lot. They may also process multiple lots at the same time, depending on the lot size relative to the batch size.

FabTime Response: The number of wafers that can be processed at one time in a Per-Batch tool is generally larger than the number of wafers in the lot. In our experience (and Jennifer has a master's thesis on Per-Batch tools) the number of wafers that can be processed at one time is NOT the same as the number of wafers in a lot. It is larger. This is what we mean when we talk about Per-Batch tools (otherwise, where there is a lot size/batch size matchup, we would consider a tool to be a Per-Lot tool). This appears to be just an issue of semantics. The point, for the lot size discussion, is that if you have more, smaller lots, you'll have to group more lots together on batch tools (or run with smaller total batches, but this can lead to capacity issues), which can increase the challenge of dispatching decisions.

4. **Cluster Tools and Lot Size:** as a comment for future reference rather than an error, my colleagues and I have previously propagated the concept of "ineffective usage of the cluster tools" as "Material Starvation", which is currently being used as a common term of reference within the semiconductor industry. This concept was first introduced in a ballot change to SEMI E94 in 2007, and will be referred to again in an upcoming ASMC paper in May 2014 on "Predictive Carrier Logistics" (PCL), and within the current SEMI Predictive Carrier Logistics Task Force.

FabTime Response: We will keep that term in mind. We have not run across it.

5. **Material Handling**: the article states: "For fabs with automated material handling, the system may be configured for the larger lot sizes, and could be costly or disruptive to change. Just grouping two smaller lots into the space previously taken up by a single lot could lead to misprocessing errors (since you wouldn't necessarily know what wafers were in each lot from the outside)."

Fabs typically track which wafers are in each lot very precisely because that is a vital and necessary component of Yield Engineering.

FabTime Response: Fair enough.

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

Helping People to be Better Problem-Solvers

Introduction

By Frank Chance and Jennifer Robinson

Here at FabTime, we spend a fair bit of time trying to help people solve problems. The day-to-day problems that we are working on often have to do with data in some way. For example, an internal report created by a customer site might show a different number for total WIP than FabTime shows. Alternatively, sometimes we are working internally to track down some sort of software bug that causes an undesirable outcome (which could, in turn, be a data discrepancy). And sometimes we are offering a customer advice regarding some behavior on the floor that isn't what the site expected or what the site desires.

All of these scenarios share a common link. In order to solve the problem, we need to identify the root cause. And yet, it strikes us, time and time again, that, well, people aren't necessarily good at finding root causes. Here are three common behaviors that we see that prevent people from getting to the necessary root cause of a problem:

1. Failing to be a skeptic;

2. Making undocumented assumptions that aren't true; and

3. Not digging deeply enough into the data.

Skepticism

Last fall, when Frank was putting together his introductory remarks for our user group meeting, he initially wanted to build his remarks around a story that Steve Jobs told many times. Jobs said that when he was young, he saw an article in Scientific American about the relative efficiency of

different species. For example, how many calories does it take an animal of species X to go one mile. In the original list, humans weren't even in the top ten. The most efficient animal was the condor. However, if you put a human on a bicycle, he goes right to the top of the list. This is because humans are tool-makers. We have come up with ways to overcome our natural limitations. Jobs said that this is how he thinks of a computer, as a bicycle for the mind.

Frank thought that this was a great story. However, before building his comments around it, he wanted to find the original article, and see it for himself. However, after many hours of searching online, he couldn't find the article. Instead, he found:

1. Many video clips where Steve Jobs tells the same story, including one in which he appears to have the article in hand. The camera pans across a scientific-looking article, showing some reasonable-looking text and a few graphics. But it never shows page numbers or an issue number.

2. Many references to the story by other people who either worked at Apple or heard Steve Jobs tell the story.

3. Several people asking the same question that Frank was asking, namely "exactly what issue of Scientific American contains this article"?

4. Some references to people saying "it's in issue X of Scientific American."

5. A text list of the table of contents from Scientific American for roughly 1965-1979, none of which appeared to contain the article. He even found the particular issue that people have claimed contained this article, and there is nothing that seemed even close to it.

In the end, Frank didn't have time to pursue what seemed to be the only way to find the article, which would be to go to a library, see if they had every issue of Scientific American from 1965 to 1975, and go through those issues one by one, looking for the article. He ended up going in a different direction for his User Group Meeting remarks.

The point of this example is that some stories sound so good that we assume they must be true. This is why we see urban legends spread on Facebook and in emails. Most of us have likely been taken in by one of them. But if we don't have proof, how can we know that they are true? Unless we are presented with the evidence, we cannot confirm that the story is true. The only fact we have confirmed is that person X said Y is true. That is NOT the same as confirming that Y is true.

To avoid being taken in, we must train ourselves as skeptics. We recently read an article that referenced the Latin phrase "Nullius in verba," which encapsulates this point nicely. "Nullius in verba," or "take nobody's word for it" is the slogan for the Royal Society of London for Improving Natural Knowledge. Here is a quote from their website:

> "The Royal Society's motto "Nullius in verba" roughly translates as "take nobody's word for it". It is an expression of the determination of Fellows to withstand the domination of authority and to verify all statements by an appeal to facts determined by experiment."

If we fail to be skeptics, we increase the difficulty of problem-solving.

Undocumented Assumptions

A related (and insidious) issue is undocumented assumptions that creep into our day to day problem-solving.

We see this behavior sometimes in troubleshooting FabTime problems. A customer might say: "FabTime just started doing X, which is wrong." There are at least two undocumented assumptions in this statement (that it just started happening, and that it is wrong). If we

accept these two assumptions without questioning them, we can potentially spend a lot of time going down the wrong investigative path.

Instead of assumptions, what we need in this case are questions, such as:

- When did this problem start happening? Can we pinpoint an event that may have triggered it?

- What seems to be going on? What data makes it seem that way? What do we think is supposed to happen?

Of course we don't intend to single out our customers here. Undocumented assumptions can be an issue for anyone. Here at FabTime, we find ourselves making these sorts of mistakes every week, even as we are making a conscious effort to avoid them. We thought that the effort to improve problem-solving productivity might be of general interest to our readers.

If we could give one piece of advice to you, our newsletter subscribers, to help you to solve problems in your fab, it would be this: document and question your assumptions. Don't be fooled by what seems to be the case, even if you can come up with a plausible story that explains the data. Perhaps you had a catastrophic downtime this week on one tool, and you also observed a low OEE on your bottleneck. The easy path is to say: "Oh, starvation or arrival variability due to that downtime caused the OEE loss on the bottleneck." But until you dig into the situation, that's just an assumption. You might be missing some other thing that happened, something that you could avoid in the future if you understood it better.

We have found that the act of listing unverified statements as assumptions (labeled in all-caps, e.g. "ASSUMPTION: X is true") is usually enough to trigger the thought-process "I wonder if X really is true?" And that leads us to check the assumption – and often to a solution.

Digging into the Data

Related to the above-discussed issues of documenting and questioning assumptions is the more specific issue of making assumptions about data, instead of looking for what the numbers actually show. Suppose, as mentioned above, that we are troubleshooting an issue in which an internal customer report shows X wafers in a particular area, while a chart in FabTime shows Y wafers in that same area. No amount of looking at X and Y is going to solve the problem. The way to identify the problem is this:

1. Confirm that the two reports represent the same point in time (since WIP is a point in time metric), and don't have any hidden filters. (Don't assume that there aren't hidden filters - check!)

2. Make a list of the lots that make up X and another list of the lots that make up Y. Sort them the same way, and go through, one by one, until you find a lot that is on one list and not the other.

3. Research that lot. Where does the other system think it is? Is it showing up as active in both systems? Etc.

This is how you will solve the problem. By figuring out exactly where there is a discrepancy, at the lowest level you can look. In the above example, if all of the lots match, but the total WIP is still off, then you'll need to look at the number of wafers in each lot. Somewhere, if you dig down deep enough, you will find the problem.

For another example, some of us still balance our checkbooks manually. When you go to balance your checkbook, and there's a discrepancy, it's pretty clear what you need to do:

1. Run the calculations again, to make sure you didn't make a math error as you were adding cleared checks and subtracting those not yet cleared.

2. Check that the numbers entered in the checkbook match those appearing on the statement. Perhaps there is a transposed pair of digits or some other error.

3. Confirm that all entries in the statement have been checked off.

4. Go back and check the math in your check register, going back to where you last had a correctly balanced checkbook and moving forward.

The discrepancy will usually make itself known in one of these four steps. Sure, there are shortcuts. If you are off by $150, check for $150 entries that might have been missed first. But basically, unless you are happy having a checkbook that isn't quite balanced going forward, you have to get down to the details of the individual transactions.

What you don't do in this example of balancing your checkbook is call the bank and say: "Hey, my check register shows $957.50 but your statement shows $925.32." There is nothing that the bank can do with this information. (Though they might ask you to come in and sit down with them so that they can walk you through the above steps.) On the other hand, if you're able to say: "On this date, this check is showing as cleared for this amount, but it should have been this other amount. Here's the scan of the check showing the other amount", then you can get things fixed. (Well, maybe.)

It's the same thing with any data problem in your fab. Suppose the OEE being reported for a tool isn't what we think it should be. We can argue all day that the OEE ought to be 76% instead of 53%, but the only way to solve anything is to drill down to the components of the OEE, and keep digging deeper, until we find something concrete that isn't right. The deeper you dig, the better you can understand what's going on.

An Offer

Frank is willing to offer a prize to the first person who can produce the Scientific American article, if it exists, referenced in the Steve Jobs videos. He will donate $50 to the charity of your choice. You'll also have your name printed in the newsletter (if you agree) with our thanks.

Conclusions

Whether you are a software vendor looking for bugs, or an equipment engineer trying to improve uptime, or a manufacturing manager who wants to know why one shift has lower productivity than another, you have to be able to find root causes. In our experience, there are three things that repeatedly keep people from solving these types of problems effectively. The first is failing to be a skeptic, and thus heading off in the wrong direction from the first step. The second (and related) problem is making undocumented assumptions about a situation, and thus missing the opportunity to solve the right problem. The third is not taking the time to roll up one's sleeves and dig as deeply as necessary into the nitty gritty data.

Here is our advice to you, honed from decades of consulting, software troubleshooting, and model debugging:

- Be a skeptic (Nullius in verba).
- Document and question your assumptions.
- Dig deeply into the data, rather than staying on the surface.

If you can do these things, no matter what your job is, you're more likely to be successful in solving problems.

Subscriber List

Total number of subscribers: 2793, from 435 companies and universities.

Top 20 subscribing companies:

- Intel Corporation (153)
- Micron Technology, Inc. (140)
- Maxim Integrated Products, Inc. (130)
- International Rectifier (120)
- Fairchild Semiconductor (98)
- GLOBALFOUNDRIES (87)
- Texas Instruments (72)
- Carsem M Sdn Bhd (71)
- ON Semiconductor (70)
- X-FAB Inc. (62)
- STMicroelectronics (55)
- Western Digital Corporation (54)
- Freescale Semiconductor (53)
- Analog Devices (51)
- Infineon Technologies (50)
- Skyworks Solutions, Inc. (50)
- IBM (48)
- Seagate Technology (43)
- Cypress Semiconductor (33)
- ATMEL (31)

Top 4 subscribing universities:

- Ecole des Mines de Saint-Etienne (EMSE) (17)
- Arizona State University (8)
- Nanyang Technological University (7)
- Virginia Tech (7)

New companies and universities this month:

- Boston Consulting Group (BCG)
- Glo-USA
- GT Advanced Technologies
- Technical University of Hamburg

Sampler Set of Other Subscribing Companies and Universities:

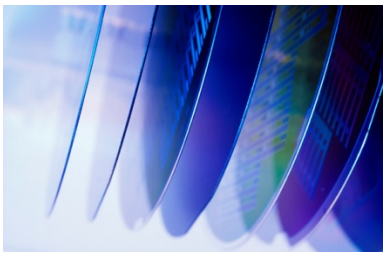
- Albany Nanotech (3)
- AU Optronics Corporation (4)
- AUO Sunpower Sdn Bhd (1)
- Central Graphics (1)
- Crocus Technology (2)
- Foothill Technology (1)
- GE (1)
- Globosat Canais (1)
- HL Electronics & Engineering (1)
- Hutchinson Technology (1)
- Indian Sugar + General Eng. Corp. (1)
- L-3 Communications (3)
- LG Display (1)
- micMAC Global Inc. (1)
- Nepes Pte Ltd (1)
- QMAT Inc. (1)
- Ralls Construction Corporation (1)
- Silterra Malaysia Sdn. Bhd. (26)
- TRW (2)
- Zetek PLC (3)

Note: Inclusion in the subscriber profile for this newsletter indicates an interest, on the part of individual subscribers, in cycle time management. It does not imply any endorsement of FabTime or its products by any individual or his or her company.

There is no charge to subscribe and receive the current issue of the newsletter each month. Past issues of the newsletter are currently only available to customers of FabTime's web-based digital dashboard software or cycle time management course.

To subscribe to the newsletter, send email to newsletter@FabTime.com, or use the form at www.FabTime.com/newsletter.htm. To unsubscribe, send email to newsletter@FabTime.com with "Unsubscribe" in the subject. FabTime will not, under any circumstances, give your email address or other contact information to anyone outside of FabTime without your permission.

FabTime® Dispatching Module



Dispatch Configuration and Support

We offer our dispatching module for a single, fixed monthly fee (on top of your regular FabTime subscription). This includes:

- Dispatch rule configuration via user-friendly web-based interface for standard factors
- Training.
- Dispatch list feed to the MES (if applicable).
- Support and upgrades.

Custom dispatch rules and consulting from our dispatching expert available for additional fee

Dispatch Factors

- Batch code at the current tool.
- Lot priority.
- Downstream tool priority.
- Current tool FIFO.
- Current tool idle time.
- Downstream batch efficiency.
- Critical ratio.
- Earliest-due-date.
- Current step processing time.
- Remaining processing time.
- Current step qualified tool count
- WIP level or staging time at downstream tools.

Interested?

Contact FabTime for details.

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Phone: +1 (408) 549-9932
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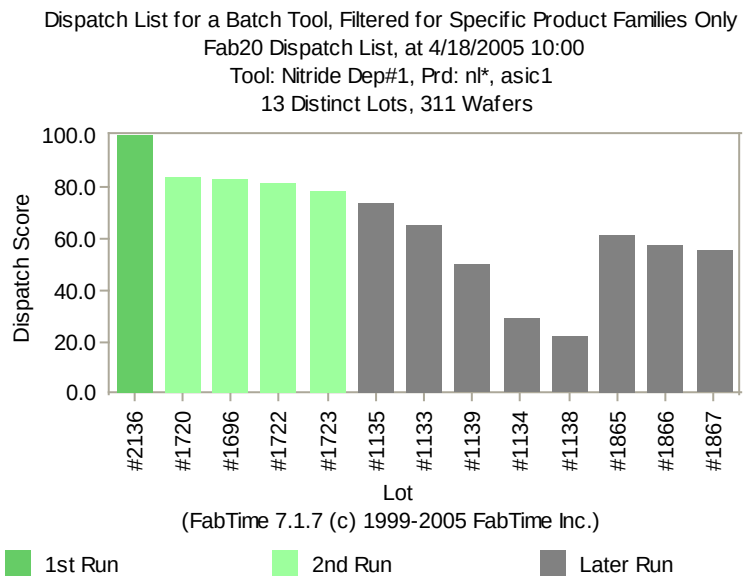
Email: Sales@FabTime.com
Web: www.FabTime.com

Do your operators make the best possible dispatching decisions?

- Do you struggle to balance lot priorities and due dates with tool utilization and moves goals?
- Do your critical bottleneck tools ever starve?
- Do you use standard dispatch rules, but feel that your fab's situation is more complex, requiring custom blended rules?
- Do you know how well your fab executes your dispatch strategy?

FabTime's dispatching module is an add-on to our **web-based digital dashboard software**. At any point, for any tool in your fab, FabTime will show you the list of all lots qualified to run on that tool. This list will be ordered by the dispatching logic that your site has selected for that tool. This logic can use standard dispatch rules such as Priority-FIFO and Critical Ratio. However, you can also create custom dispatching logic using any combination of dispatch factors (shown to the left).

You can display dispatch lists in FabTime, and/or export them back to your MES. FabTime also includes a dispatch reservation system to hold downstream tools when a lot is started on an upstream tool, as well as dispatch performance reporting.



FabTime Dispatching Module Benefits

- Ensure that wafers needed by management are in fact the wafers that are run, while requiring less manual intervention on the part of management.
- Improve delivery to schedule, and the display of performance to schedule.
- Document the dispatching logic used by the best operators and make this available to all shifts.