FabTime Cycle Time Management Newsletter

Information

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

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. New features in development right now include new Tool Average Availability vs. CV of Availability Chart and the ability to move charts more quickly on home page tabs.

Editor: Jennifer Robinson

Keywords: Factory Behavior; Metrics and Goals; Reporting; Statistics

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Welcome

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.

Thanks for reading – Jennifer

Community News/Announcements

Call for Papers: e-Manufacturing & Design Collaboration Symposium 2018

Conference Date: 9/7/2018

Paper Submission Due Date: June 1, 2018

Scope: The Symposium attends to recent technological advancements to align the needs of designers, manufacturers, equipment suppliers, software vendors, solution providers and researchers. It offers a public arena for the exchange of up-to-date experiences among manufacturers for adoption of technological developments. With green notions of supply/engineering/value chains, coverage of the joint symposium includes, but is not limited to, the following topics of interests (list shortened by FabTime):

- Benefits and Justification (ROI, CoO, OEE ...)
- Big Data / Analytics / Machine Learning / AI
- Data Collection / Quality / Storage / Management
- Design for Manufacturing / Testing / Yield
- e-Diagnostics, e-Manufacturing, EEC
- Fab Management / Scheduling / Dispatching
- Factory Integration / Physics / Operations / Queueing
- Final / Lean / Green / Smart / Intelligent Manufacturing
- Manufacturing Control and Execution Systems
- Manufacturing Strategy and Operation Management
- Predictive / Preventive Maintenance
- Yield Enhancement and WIP Management

For more information please refer to the conference website.

Next Fab Owners Alliance Meeting to be Held May 24 in Fort Collins, CO

In 2018 the FOA was integrated into the SEMI family, and re-named from Fab Owners Association to Fab Owners Alliance. More details can be found on their new website. FabTime remains a member of the FOA, as do many of our friends and customers.

The Q2 meeting of the FOA will be held at Broadcom in Fort Collins, CO on May 24th. FabTime's Jennifer Robinson will be present for the Wednesday evening social on May 23rd, and would love the chance to talk to any newsletter subscribers who might be in attendance.

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

Subscriber Discussion Forum

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Simply send your contributions to Jennifer.Robinson@FabTime.com. We have no subscriber discussion at this time.

FabTime User Tip of the Month

Add a Trendline to any FabTime Chart

We recently asked the members of the FabTime virtual user group for suggested topics for the tips of the month. One person pointed out that we had not directly discussed the new trendline feature. We are correcting that oversight now.

We did share a tip a couple of years ago about ways to Edit Individual Charts. However, we did not at that time discuss the "Trend" option available as part of the chart editing interface. The Trend option tells FabTime to generate and draw a trendline for the selected variable. The trendline uses linear regression to draw a straight line representing the overall trend in a set of values.

For example, suppose we are looking at the scrap by shift over a two week period. In this case, the scrap rate varies considerably by shift, and it's difficult to

determine at a glance whether it is trending upward (probably) or not. An example is shown below.

Adding a trendline makes the picture much clearer. To add a trendline, click "Edit Chart" below the chart image. Then check the box in the "Trend" column for either "Actual Above Goal Units" or "Actual Below Goal Units". Checking either (or both) of these will cause FabTime to generate a single trendline reflecting all of the bars of the chart (the ones above the goal and the ones below the goal). The trendline appears as a black, dashed line. The upward trend in scrap is quite clear, as shown in the chart at the top of the next page.

Putting your mouse over the trendline will cause FabTime to display the line slope, as shown. In this case, scrap is increasing at a rate of 1.4650 wafers per shift, on average across the two week period. The total
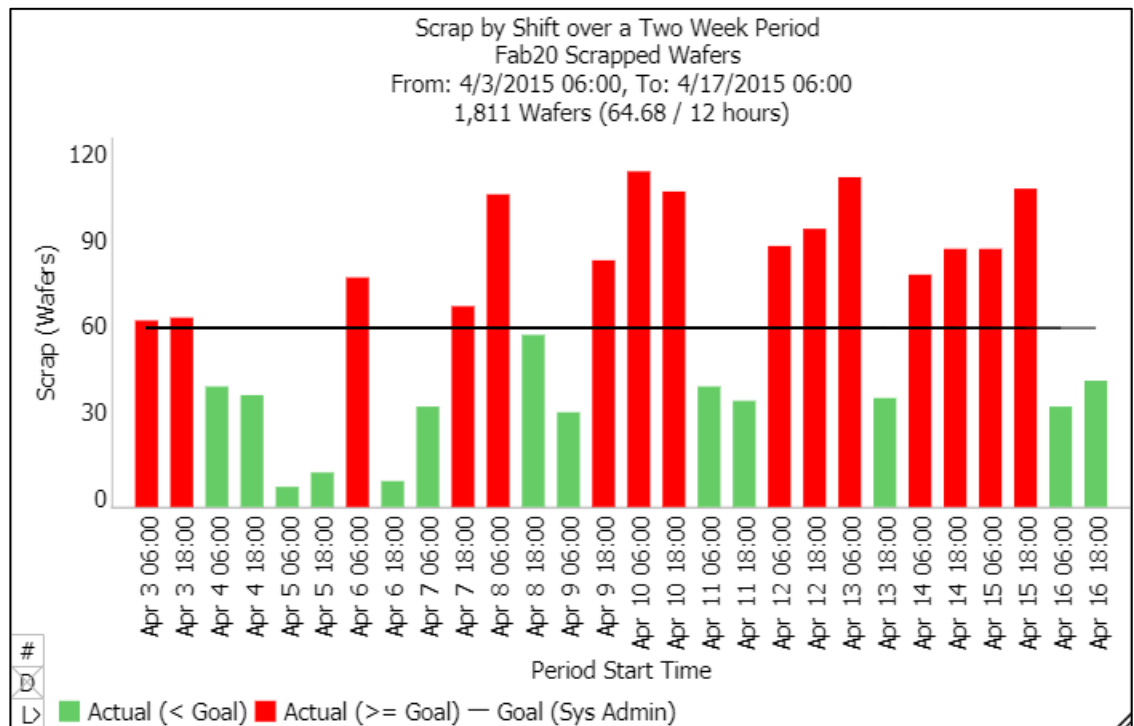

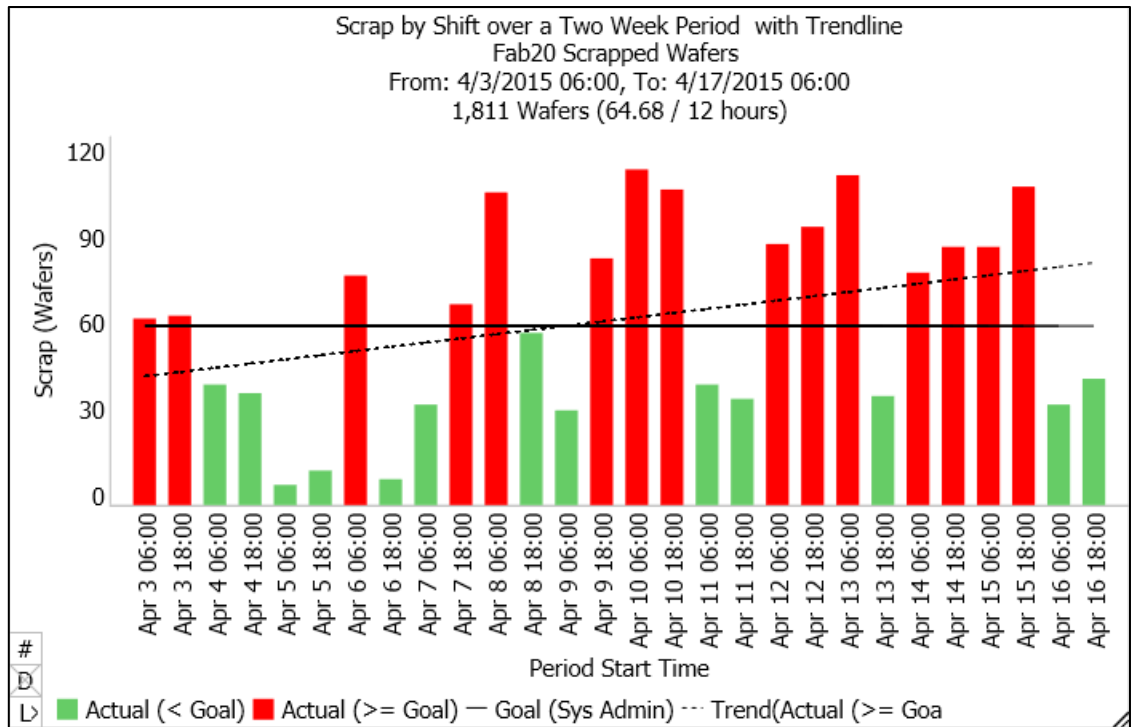**Figure 1. Example of Scrap Trend by Shift, Relative to Goal**

Figure 2. Scrap by Shift with Trendline Showing Increase over the Time Period

increase from the left-hand end of the trendline to the right-hand end of the trendline is 41 wafers.

For stacked charts (e.g. WIP Stacked Trend) FabTime will calculate the trendline based on the total height of each bar.

Trendlines can also be applied to variables that display as lines instead of bars. Multiple trendlines may be displayed on the same chart (if there is more than one data series), though this may make the chart confusing to look at. Trendlines can be added to Pareto charts, though the situations in which this will be useful are limited. One can imagine using a trendline on a WIP Pareto by sub-segment, sorted in production order, to know if the WIP is piling up more in the front or backend of the line. Primarily, however, the trendline feature is most useful on trend charts.

We hope you find the trendline feature useful. If you do not see the "Edit Chart" option enabled at your site, please contact your local FabTime administrator.

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!

Using Trendlines to Improve Fab Performance

Introduction

As described above, FabTime has a relatively new feature that allows users to apply trendlines to factory performance charts. In our tip above, we outlined the technical details about how to use the feature. In this article, we talk more generally about using trendlines to understand and improve fab performance.

We outlined a specific example of applying a trendline to Dynamic X-Factor charts back in Volume 15, No. 5 (email newsletter@FabTime.com to request a copy of that issue). More generally, it can be useful to apply a trendline to any performance measure that is reported as a trend over time (and occasionally to other metrics). A linear trendline tells you whether a metric is trending upward or downward, or staying flat.

In most cases, we'd like to see scrap and factory cycle time trending downward, WIP turns trending upward, and overall fab WIP declining (because, via Little's Law, this means that cycle time is probably declining). Of course during a ramp we might expect WIP, and consequently factory cycle time, to be increasing, but we would still aim for that improvement in scrap. And in this case, the slope of, say, a moves trendline could tell us whether the ramp is progressing at the target rate.

Over shorter-term time windows, and at more granular levels of the fab, however, it may be that the goal is simply to keep a metric stable over time. Trendlines are useful for that too, especially when the data varies quite a bit from day to day. With arrivals to individual tool groups, for example, the goal is usually consistency rather than some upward or downward trend.

Similarly, when looking at WIP by segment of the line, the goal may be for there NOT to be an upward or downward trend, because an upward trend would suggest that WIP was piling up in the back of the line, and vice versa. An example where WIP levels are higher in the back of the line is shown below.
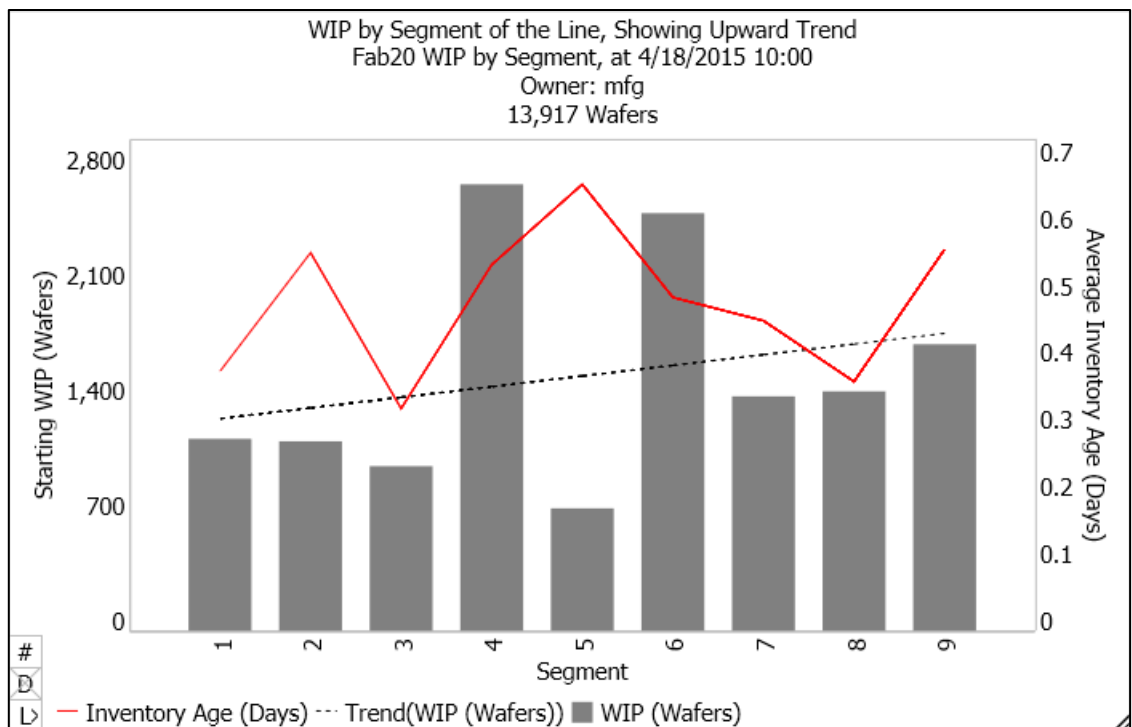

Figure 3. Example of WIP by Segment of the Line, Trending Upward

Here are a few examples of potentially useful linear trendlines applied to fab performance charts:

■ Trend in factory cycle time over time (e.g. over the past 12 months)
■ Trend in overall scrap over time
■ Trend in availability for a key tool or tool group
■ Trend in overall WIP turns for the fab (this is a predictor of the trend in cycle time)
■ Trend in overall OEE for an area (are improvement efforts working?)

But really, the examples are limitless. It can be worth looking at the trend of any variable that you already care enough about to be monitoring. The trendline smooths out variability, and gives you a quantitative answer for the question of whether things are improving or not.

Adding a trendline also gives a view into the amount of variability in a metric. Just seeing the line we can tell quickly if the points are all close to the line, or all over the place. While we can sometimes see this anyway, having the line in place sharpens our visual acuity, particularly when we are looking at bar charts.

Predictions and Non-Linear Data

Although it's quick and easy to add a linear trendline to a set of data points, we can't always assume that short-term linearity will remain going forward. For instance, scrap may be declining linearly right now, but as the scrap rate gets very low, this is bound to level out. You can never cross the zero line, of course. And the problems that remain after the first pass problems are solved will tend to be less tractable, slowing improvement efforts.

In general, we can't assume that any trend will continue going forward. But over short time horizons, in the absence of changes in how the fab is operating, it may be possible to make some limited assumptions. If we're in the middle of implementing a setup reduction strategy, and we're seeing an improvement in the trend chart, it's reasonable to expect that if we continue down the same path, we'll continue to see some improvement, though probably not at the exact same rate.

Some trends are, of course, non-linear. The most notable example is the relationship between cycle time and utilization. While this graph, called an operating curve, might look linear at low to moderate utilizations, at high utilizations cycle time increases exponentially. A linear trendline is not useful above some utilization value. But cycle time vs. utilization is not something that fabs are generally looking at on a day to day basis anyway (because both are changing in the short-term due to other variables, such as downtime). More generally, if you were to try to apply a linear trendline to some chart for which the underlying relationship was non-linear (e.g. quadratic or exponential) what you would probably see is a line that doesn't fit very well.

Polynomial trendlines are used when data fluctuates according to some pattern. Logarithmic trendlines are used when a value increases or decreases but then levels out, as in the scrap example mentioned above. Quadratic or exponential trendlines occur in some cases, as with the operating curve just discussed. Fitting these more complex trendlines usually requires more data, and/or some understanding of the likely underlying pattern of the data. While this may be useful in some special cases, this is probably not the route to take in looking at day to day fab performance charts. Rather, we recommend the simplicity of applying a linear trendline to a set of values to look for general up/down trends.

Skepticism in the Application of Trendlines

As with most things chart-related, it is possible to cherry-pick data to fit a particular narrative. For example, it might be that the trendline on availability for a

key tool group displays an upward slope from Sunday to Sunday. But it is certainly not out of the question that the trendline will look very different from Monday to Monday, if the availability was particularly poor on the first Sunday, and/or is poor on that second Monday. And, of course, in some cases we can filter out individual tools because they are "exceptions", without mentioning that, and still brag about the overall trend. These issues are mitigated as more data is included in the chart.

We can't tell you exactly how much data you need to draw valid conclusions in general, of course, because the answer will depend on the specifics of each situation. So we simply leave you with a suggestion to be skeptical of a single trendline (as you should be of many graphs that you see in the media). We recommend that you experiment with changing the start and end points to ensure that the result you are seeing is valid before drawing firm conclusions.

Conclusions

If you search the web for information about trendlines, you'll find that most of the results that come up are related to the stock market. This makes sense, in that people buying stocks are in the business of making sense of huge amounts of data that change over time. But people who run wafer fabs are also in the business of making sense of data, looking at metrics to decide what is going well and what needs to be improved. FabTime believes that applying trendlines to factory performance charts offers fab management additional information that may be useful in this regard.

Much of the day to day data in a wafer fab is highly variable, from starts to shipments to (especially) arrivals and cycle times at individual tools. Trendlines offer a quick way to smooth out this variability and identify problems that might be otherwise masked for a time. Even a small upward

trend in scrap rates is something we want to identify right away, as is a downward trend in throughput at the bottleneck. The slope of a linear trendline offers quantitative information about how quickly things are changing, which tells us how serious the problem is.

While there are many possible shapes for trendlines (exponential, logarithmic, polynomial, etc.), finding the right fit for such trendlines can require a fairly large amount of data, as well as the experience to know what type of equation to fit. For day to day fab performance improvement efforts, this is probably overkill. Adding a linear trendline to a set of points, however, is a quick and easy thing to do, one that will give useful information in many cases. We recommend that fabs give it a try!

Further Reading

■ This tutorial by Emily Cadic at Study.com offers general information about how to calculate trendlines: https://study.com/academy/lesson/what-is-a-trend-line-in-math-definition-equation-analysis.html

■ J. Robinson and F. Chance, "Using Trend Lines to Enhance the Value of Dynamic X-Factor Charts," *FabTime Newsletter*, Vol. 15, No. 5, 2014.

Closing Questions for Newsletter Subscribers

Do you routinely use trendlines on any of your factory performance charts? Are there other uses for trendlines in fab analysis that we have neglected to mention here?

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- Infineon Technologies (146)
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- GLOBALFOUNDRIES (110)
- Maxim Integrated Products, Inc. (98)
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- Seagate Technology (52)
- TDK (includes RF360)   (46)
- Analog Devices (41)
- Zymergen (35)
- Honeywell (30)
- ABB (28)

Top 3 subscribing universities:
- Ecole des Mines de Saint-Etienne (EMSE) (15)
- Arizona State University (8)
- Virginia Tech (7)

New companies and universities this month:
- Binghamton University
- D&V Consulting LLC

Sampler Set of Other Subscribing Companies and Universities:
- font
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- Celerant Consulting (1)
- Cornell University (1)
- Diodes-FabTech (2)
- Draper Laboratory (3)
- KAIST (2)
- MiaSole (1)
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- Novati Technologies (8)
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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.

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FabTime® Cycle Time Management Training

"It was helpful to see best-in-class methods for wafer fab cycle time management. Discussing these matters in-depth with you was quite valuable, as we could ask questions specific to our fab and processes."

Shinya Morishita
Manager, Wafer Engineering
TDK Corporation

Course Code: FT105

This course provides production personnel with the tools needed to manage cycle times. It covers:

- Cycle time relationships
- Metrics and goals
- Cycle time intuition

Price

$7500 plus travel expenses for delivery at your U.S. site for up to 20 participants, each additional participant $300. Discounts are available for multiple sessions.

Interested?

Contact FabTime for a quote.

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Do you make the best possible decisions?

- Do your supervisors possess good cycle time intuition?
- Are you using metrics that identify cycle time problems early?
- Can you make operational changes to improve cycle time?

FabTime's Cycle Time Management Training is a one-day course designed to provide production personnel with an in-depth understanding of the issues that cause cycle time problems in a fab, and to suggest approaches for improving cycle times. A two-day version and a half-day executive management version are also available upon request. The course is only available for delivery at sites within the United States, unless it is delivered in conjunction with software training for FabTime customers.

Prerequisites

Basic Excel skills for samples and exercises.

Who Can Benefit

This course is designed for production personnel such as production managers, module managers, shift supervisors, hot lot coordinators, and production control.
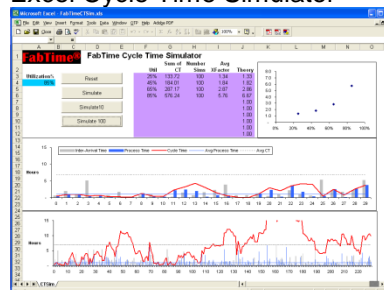
Skills Gained

Upon completion of this course, you will be able to:

- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition to operational decisions.

Sample Course Tools

Excel Cycle Time Simulator

Staffing Delay Simulator