# 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 the current release of FabTime include a date/time popup control and support for user-selected trend lines on JavaScript charts.

**Editor:** Jennifer Robinson

**Keywords**: Dynamic X-Factor; Metrics and Goals; Fab Management

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## Welcome

Welcome to Volume 15, Number 5 of the FabTime Cycle Time Management Newsletter! As summer draws to a close, we are keeping busy with several new FabTime software installations. We've also just released a new version of the product, with some upgrades that customers have been looking forward to (see below for details). Our FabTime software tip of the month is about accessing and using our new JavaScript charting engine. We also have a response to the last issue, about open problems in managing fabs.

In our main article this month, we revisit dynamic x-factor (DXF), a fab performance metric that has not been discussed in the newsletter in several years, and look at how the usefulness of DXF charts is enhanced via the addition of trend lines (regression). We are interested to hear feedback from our subscribers on whether and how you are using this metric, which we continue to think can be quite valuable for fab management.

Thanks for reading – Jennifer

# Community News/Announcements

### FabTime Releases Patch106

August 26, 2014 -- FabTime is pleased to announce the production release of core patch 106 to all customers currently on subscription or maintenance contract. Key features in this new release include:

1. Trend lines (regression lines) on JavaScript charts via "Edit Chart" control.

2. Date/time popup control for StartTime/EndTime/AsOfTime on individual chart pages. Users may still type in date/time filter values, but may also use the popup control to select date/time values.

3. Instant-editing of JavaScript charts: as soon as a change is made in the "Edit Chart" control, it is reflected on the chart, without any delay or server-side requests.

4. JavaScript-only option for new sites that do not purchase ChartFX. Existing sites may also choose to transition to JavaScript-only charts to simplify support, or when installing a new FabTime server. FabTime administrators may now set the chart engine using the "Configure FabTime" interface.

5. Site control to require user-level permissions for EditChart. If user-level permissions are required, they are displayed on "Manage Users" page.

FabTime's development team is already hard at work on Patch107.

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

### Enable JavaScript Charts in FabTime

If your site has installed a recent production release of FabTime (Patch 105 or higher), then you now have the capability to use FabTime's JavaScript charting engine, instead of the previous charting engine (ChartFX). Building our own charting engine in JavaScript has allowed FabTime the flexibility to add new features to charts. New capabilities currently available with the JavaScript charts include drag-to-resize, pop-up data values, and the ability to change the legend format.

If you are on a chart page, and would like to view the JavaScript version of the chart, simply select "JavaScript" from the "Active" drop-down, and press the "Go"

button below. You will know that you are seeing the JavaScript version when you see two small diagonal lines in the lower right-hand corner of the chart.

To view your home page charts as JavaScript charts, use the new "Format-all tabs" control in the lower left-hand corner of the Home page. Select "JavaScript" from the drop-down list and press "Go".

To change the default format for charts that you generate from the chart list, use the "Active" control at the very bottom of the list of default filters on the left-hand side of the Chart page. Select "JavaScript" and press "Set Defaults".

Here are the directions for using the current JavaScript chart capabilities:

1. Pop-up values of chart data. Simply place your mouse over a chart column or line. The values associated with that data point will appear in a text box.

2. Drag the chart to resize. Place your mouse in the lower right-hand corner of the chart (where there are two diagonal lines), click, and drag. Release to select your desired size.

3. Quick-click to change the legend display (none, in line with columns, or along the bottom of the chart). In the lower left-hand corner of the chart, click on the upper-case L in the small box. A right-arrow in the box indicates that the legend will be displayed immediately to the right. An arrow in the upper right-hand corner of the box indicates that labels will be shown on or beside the chart columns or lines. An X over the L indicates that no legend will be displayed.

4. Dynamic/static chart display. When the box in the lower left-had corner of the chart (above the legend control) displays a D, this means that the chart is in dynamic mode (and mouse-over will work). If you click on the D, the box will toggle to display a D with an X over it. This means that the chart is no longer dynamic. You can view it, but can't use mouse-over or modify the legend display. Making a chart static can be helpful, particularly in older browsers, by making the chart easier to copy and paste into other applications.

In future tips, we will discuss the new "edit chart" capability, which is particularly helpful with JavaScript charts, as well as the trend line capability.

We are pleased that the JavaScript charts offer FabTime's developers flexibility in adding new functionality. We hope that you find these charts useful.

Subscribe to the separate Tip of the Month email list (with additional discussion for customers only). Thanks!

# Subscriber Discussion Forum

### Issue 15.04: Important Fab Management Problems to Solve

In the last issue, we asked where our subscribers think we should be focusing our efforts here at FabTime to help you all make fabs more productive. We only received one response to this question: "Managing Bottlenecks is crucial, especially at cluster tools".

Apparently, everyone else finds managing their fabs to be a straightforward process, with no open issues. (If this is not true, and you have any feedback regarding critical fab management problems that we should be thinking about as a community, please let us know.) Here at FabTime, we are working on improving reporting for cluster tool performance - stay tuned!

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

# Using Trend Lines to Enhance the Value of Dynamic X-Factor Charts

## Introduction

In this article, we revisit dynamic x-factor (DXF), a fab performance metric that has not been discussed in the newsletter in several years, and look at how the usefulness of DXF charts is enhanced via the addition of trend lines (regression).

## Background on Dynamic X-Factor

Dynamic x-factor is a metric that has been available in FabTime for 10 years or so. We introduced this metric to the newsletter community back in 2003 (Issue 4.08). We learned about it from a paper presented at the 2002 ISSM conference in Japan by researchers from Yasu Semiconductor (S. Johnishi, K. Ozawa and N. Satoh - the full reference is below). Dynamic x-factor is a point estimate of production line speed, used to quickly identify deviation from cycle time goals. The formula for DXF is:

**Dynamic X-Factor = Total WIP in the Line / (Non-rework WIP currently being processed on tools)**

In that newsletter issue, we defined dynamic x-factor and outlined its relation to the traditional cycle time x-factor. We concluded:

"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."

A few months later, in Issue 5.03, we discussed two applications of dynamic x-factor: evaluation of shift change coverage policies and comparison of relative performance across modules (or areas). We looked back four years later, in Issue 9.04, to discuss in detail reasons why average hourly dynamic x-factor (DXF) may be biased above or below actual cycle time / theoretical cycle time for shipped lots.

We are happy to make the three past issues on dynamic x-factor available to anyone who requests them between now and the next newsletter issue. Email your request to newsletter@fabtime.com.

## The Case for Adding Trend Lines to Dynamic X-Factor Charts

In this issue, we'd like to add one more point about the use of DXF, the fact that adding a trend line to a DXF chart makes it more useful. A trend line lets you see right away whether the cycle time in your fab is trending upward or downward, and by how much.

A primary reason to use dynamic x-factor is to have an easy-to-track metric that shows, in real time, whether cycle time in your fab is increasing or decreasing over time. When DXF is measured at frequent intervals (as we recommend; to avoid distortions), the resulting chart can be fairly jagged (particularly when there are issues with keeping tools busy at shift change). It can be difficult to eyeball a chart to mentally smooth out that noise. This is where trend lines come in.

If you add a trend line to a DXF chart, using linear regression, you smooth out the

peaks and valleys, and can quickly see longer-term trends. The slope from the regression line can be used to draw conclusions. For example, if the trend line shows a 25% increase from the start to the end of the chart time period, you can expect that if you do not do something to improve the situation, shipped lot cycle times are likely to increase in the future.
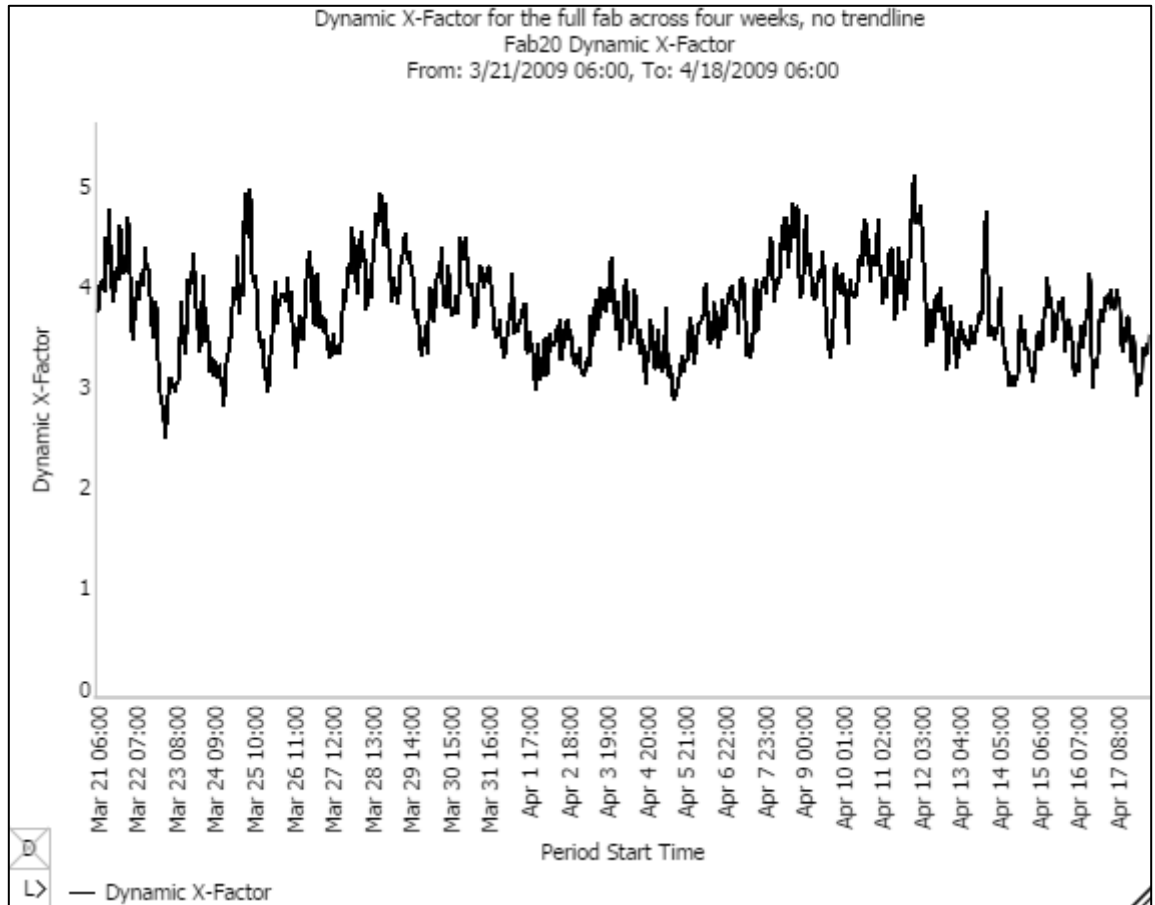
Please note that we can't say that exactly N months in the future (where N is current shipped lot cycle time) the cycle time will be exactly 25% higher - use of this data for prediction is not quite that simple. Different products in the fab have different cycle times, so we don't know exactly when the lots that are currently in the fab (and experiencing higher DXF) will ship. However, it is certainly fair to draw general conclusions that if a DXF trend line for the fab as a whole is increasing
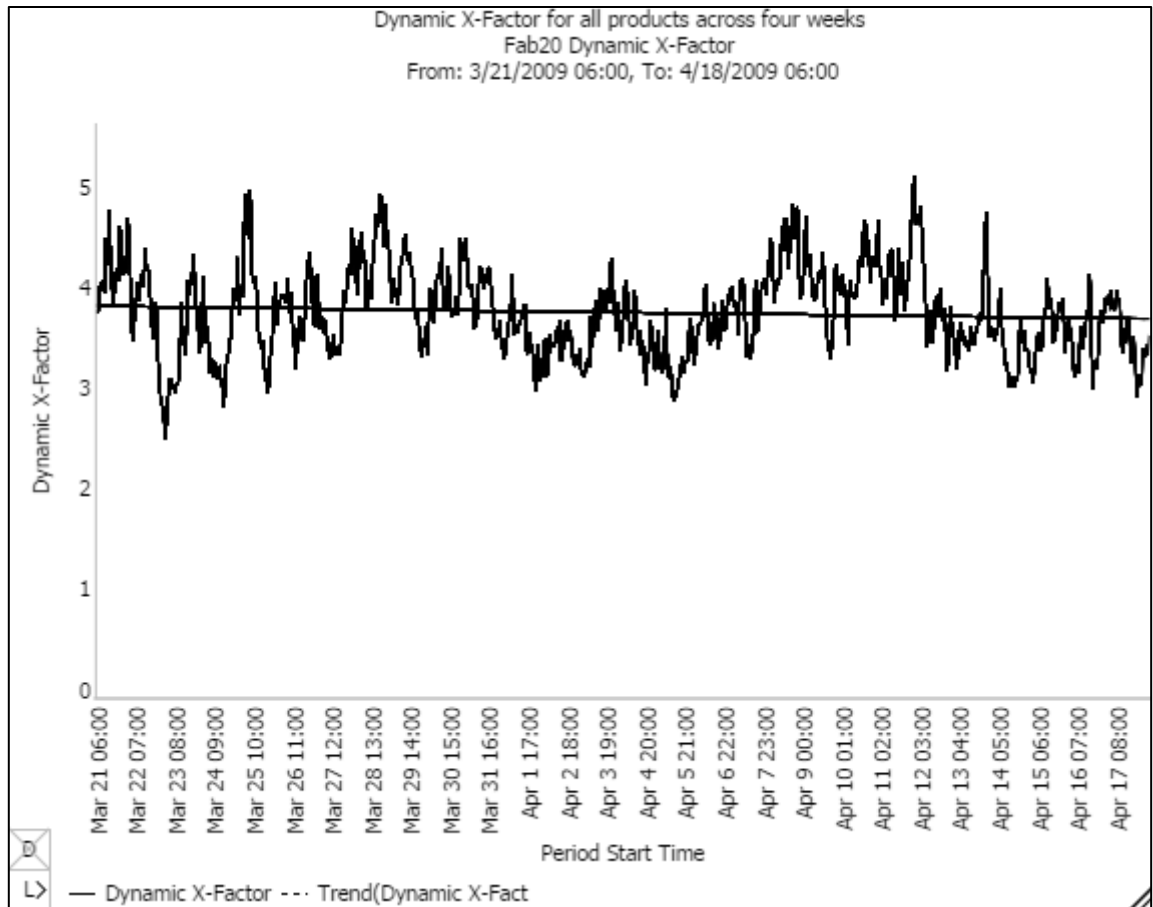
(say, over the past month) then future cycle times are likely to increase by something on the order of the same amount.

## Trend Line Examples

The chart at the bottom of this page shows DXF over a four week period, measured at the start of each hour, for a sample fab model. (The model was generated from actual fab data, but has been highly scrubbed, and is not FabTime customer data). If we look at this chart with no trend line, it appears that DXF is not increasing significantly. But it's hard to say for sure. There is quite a bit of variation from day to day.

If we add a trend line to this chart, however, we can see a bit more clearly, as shown in the example at the top of the next page.



Dynamic X-Factor for the full fab across four weeks, no trendline
Fab20 Dynamic X-Factor
From: 3/21/2009 06:00, To: 4/18/2009 06:00

Dynamic X-Factor for all products across four weeks
Fab20 Dynamic X-Factor
From: 3/21/2009 06:00, To: 4/18/2009 06:00

Though still hard to see with the naked eye, a linear regression finds that the slope of this line across the entire chart is negative 0.1272. That is, from the start of the line to the end, the dynamic x-factor decreases from about 3.89 to 3.77; a 3% decrease.
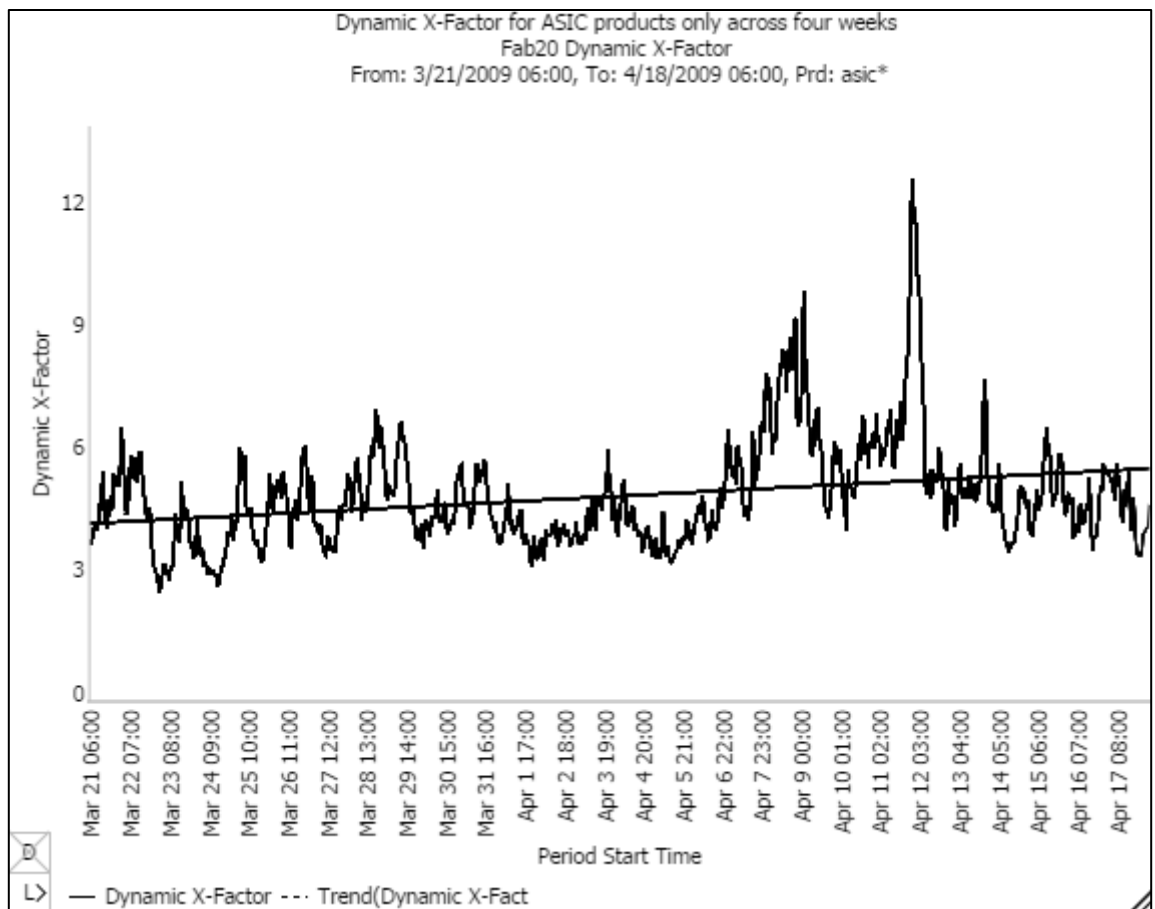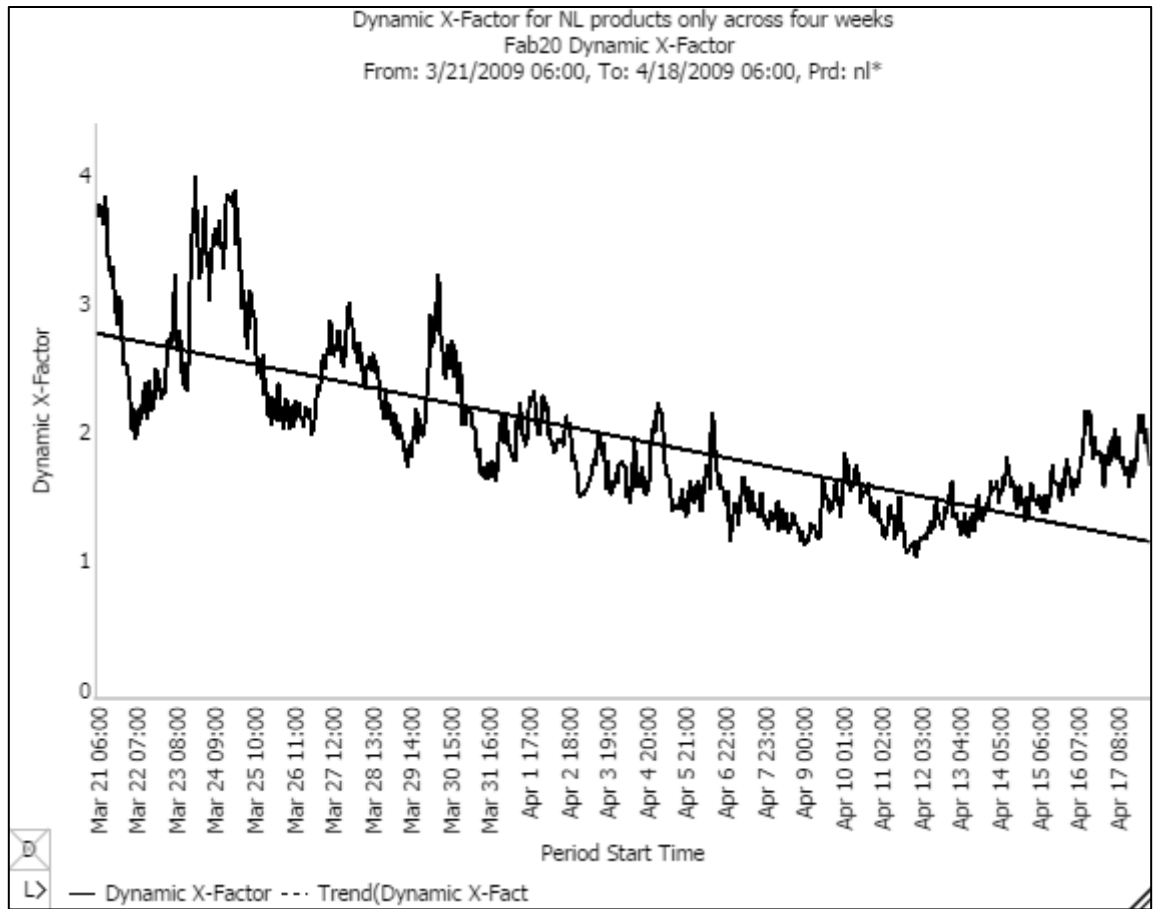
It so happens that the fab in this example has two main product lines. One, of higher priority, makes up about 20% of the WIP in the fab, while the other makes up the remaining 80%. Let's look at the DXF charts, with trend lines, for these two product lines. The trend in the DXF for the higher-priority product line is shown at the top of the next page

This fab has been making great strides at keeping the high-priority product running on tools, with a greater than 50% decrease in the DXF over four weeks. The trend line for the full four weeks is not perfect in

this case - our eye can detect a slight increase in the most recent few days. We could break this chart into shorter time periods, and note a rising trend line starting around April 11th.

As the overall DXF didn't change very much over this time period, we can expect that the lower-priority lots are paying some penalty for this improved cycle time of the high-priority lots. The trend in the DXF for the lower-priority product line is shown at the bottom of the next page, and shows, about a 30% increase in DXF over the duration of the chart.

We can also see some spikes in the chart for the lower priority lots, corresponding approximately with the lowest period of DXF for the higher priority lots. A look at the underlying data for this last chart shows that the total WIP for this product line is not changing significantly from hour

Dynamic X-Factor for NL products only across four weeks
Fab20 Dynamic X-Factor
From: 3/21/2009 06:00, To: 4/18/2009 06:00, Prd: nl*



Dynamic X-Factor for ASIC products only across four weeks
Fab20 Dynamic X-Factor
From: 3/21/2009 06:00, To: 4/18/2009 06:00, Prd: asic*

to hour. That spike where DXF rises to 12 occurs because so few lots of this product line are in process.

## Conclusions

Dynamic x-factor is a metric that helps fab managers in two primary ways:

1. It provides useful information about short-term effects, such as shift-change policies that lead to a reduction in the amount of WIP being processed on tools.

2. It shows us overall fab health, giving us an early indicator of when cycle time is trending upward.

The addition of trend lines to a DXF chart can help with this second purpose, by smoothing out fluctuations in the data, and quantifying the change in DXF (which corresponds approximately with expected changes in future shipped lot cycle time). Adding a trend line to a DXF chart is a fairly simple process, but one that we feel significantly increased the value of DXF as a metric.

## Closing Question for FabTime Subscribers

Are you using DXF in your fab? Have you used it in a quantitative way, by adding trend lines, or do you use it in a more general way? Are there other purposes besides 1 and 2 for which you use DXF? We welcome your feedback.

## Further Reading

■ S. Johnishi, K. Ozawa and N. Satoh, "Dynamic X-Factor Application for Optimizing Lot Control for Agile Manufacturing," *Proceedings of the 2002 International Symposium on Semiconductor Manufacturing (ISSM2002)*, Tokyo, Japan, 2002.

■ J. Robinson and F. Chance, "Dynamic X-Factor," *FabTime Newsletter*, Volume 4, No. 8, 2003.

■ J. Robinson and F. Chance, "Dynamic X-Factor Revisited," *FabTime Newsletter*, Volume 5, No. 3, 2004.

■ J. Robinson and F. Chance, "Dynamic X-Factor and Shipped Lot X-Factor," *FabTime Newsletter*, Volume 9, No. 4, 2008.

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# FabTime® Software for Assembly and Test

*"Instead of spending time preparing reports, shift facilitators can get the data they need quickly from FabTime, and then spend their time making real improvements."*
Mike Hillis
Cycle Time and Line Yield
Improvement Manager
Spansion Fab 25

## FabTime Subscription

One low monthly price includes
- Software installation and real-time connect to your MES
- End user and system administrator training
- Unlimited users via your Intranet.
- Software maintenance and regular upgrades (approx. 4 per year, via our no-downtime patch system)
- Add-on dispatching and planning module for a slightly higher monthly fee

## Interested?

Contact FabTime for technical details and/or a web-based demonstration.

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## FabTime's Web-Based Dashboard is Fully Applicable for Assembly & Test Facilities

- Do your customers (internal or external) want more visibility into your factory?
- Is it difficult to look at trends in equipment performance, or tie equipment performance to throughput and cycle time?
- Does your factory lack real-time reporting?

FabTime can help. FabTime saves your management team time daily by turning MES data into information, via a real-time web-based dashboard that includes lot dispatching. FabTime saves your IT staff time by breaking the cycle of custom-developed reports. Most importantly, FabTime can help your company to increase revenue by reducing cycle times up to 20% for regular lots, and even more for high-priority lots.

Although FabTime was originally designed for front-end manufacturing, you can use FabTime for your assembly or test facility. You simply need to have a transaction-based manufacturing execution system. FabTime can link to all commercial systems commonly used in the industry (e.g. WorkStream, Promis, Eyelit, Mesa, FactoryWorks) or can link to internally developed systems. FabTime can pull data from multiple databases if needed (e.g. WIP transactions from the MES, tool transactions from another system). FabTime is currently being implemented in two assembly and test facilities, with no major technical hurdles.

## FabTime Applicability for Back-End Factories

- FabTime handles lot merging and splitting, with full tracking of overall cycle times.
- All chart quantities (moves, WIP, etc.) can be displayed as die, with data tables formatted for readability of large quantity values.
- Custom assembly and test parameters (applicable to WIP or tool state transactions) can be mapped.
- Custom site-specific reports for wire bond area have been developed for customers (die and component placements, etc.).
- Custom dispatch factors allow for incorporation of back-end-specific data used in dispatch decisions (e.g. availability of boards, and minimization of sequence-dependent setups).