FabTime Cycle Time Management Newsletter

Volume 6, No. 3 April 2005

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 this version (7.0) include display of due date performance on lot progress charts and new generic WIP transaction charts (to analyze any type of WIP transaction).

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Welcome

Welcome to Volume 6, Number 3 of the FabTime Cycle Time Management Newsletter! 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.

In our new 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.

Thanks for reading!—Jennifer

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Community News/Announcements

Conference Announcement – Second ISMI Symposium on Manufacturing Effectiveness

ISMI will host its second annual Symposium on Manufacturing Effectiveness, October 24-26 2005 in Austin, Texas. This year's theme is "Accelerating Manufacturing Productivity through Innovation." Interested persons can submit abstracts and receive additional information at the conference website: www.ismi.sematech.org/ismisymposium/index.htm.

The Symposium participants will share information and methodologies for reducing manufacturing expenses in both existing and next-generation fabs. Challenges will be addressed in several parallel sessions dealing with productivity, ESH, fab design, statistical methods, modeling and simulation, yield/metrology, and e-manufacturing.

The Symposium also will offer a review focused on the Factory Integration section of the 2005 International Technology Roadmap for Semiconductors (ITRS) and a forum on critical issues facing the chip industry. Several prominent industry executives will be featured keynote speakers.

For further information, you can contact the conference organizers via e-mail at ismi.symposium@sematech.org.

If you missed last year's Symposium, this is a "must attend" for 2005. It is the key forum for understanding advances and directions in improving fab productivity.

FabTime welcomes the opportunity to publish community announcements. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

Copy Chart Images to Other Applications

Most of the time, you want to look at FabTime charts directly within the software. That way, every time you refresh a chart, it shows the most up-to-date information. However, sometimes you want to copy a chart image to another application (Word, PowerPoint, etc.). For example, you need a supporting picture to go with a presentation or other document. There are several different ways to do this, as discussed below.

1. Right-click on the chart image. From anywhere in FabTime that you see a chart, simply right-click on the chart image. This brings up a menu of options. Select "Copy" from near the bottom of the list of options. Switch to the destination application and select "Paste". Note that this is usually more successful if the chart is displayed using a relatively large size in FabTime.

2. Save the image. Newer versions of Internet Explorer display a small pop-up toolbar whenever you place the cursor

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over a chart. Click on the "Save" icon (the furthest to the left) in this toolbar. This brings up a typical "SaveAs" dialog box. The default (and recommended) option is to save the chart as a jpeg file to somewhere on your own computer. Then, from inside the target application, select "Insert | File", find the file that you just saved, and add it to your document.

3. Make the chart "active". When looking at a detailed chart page in FabTime, the "Format" controls to the lower-left corner of the screen include a drop-down box labeled "Active". The default value for this is "Never". This means that the charts displayed in FabTime are static image files. However, if you change this to "Always" and press the "Go" button below, FabTime's third party charting engine (ChartFX) will allow you to make changes to the displayed chart. The active chart view also includes an option to copy a chart image to the clipboard as a metafile (rather than the default bitmap format). This can result in higher quality images in your other applications, especially if you are converting to PDF format. To view the ChartFX copy options, make the chart active, then right-click anywhere over the background of the chart image and select "Toolbar" from the displayed options. Then click the third toolbar button from the left to copy the chart, and select your desired format (we recommend "As a Metafile"). Paste to your target application. Note that your Internet Explorer security settings may not allow you to use this functionality – contact FabTime with questions.

The important thing to remember with all three of these methods is that the charts displayed in FabTime are pictures, not editable charts like Excel charts. This means that you should re-size the chart image from inside FabTime before copying and pasting to your destination application. If you try to re-size after pasting, the chart will likely end up blurry (especially if you are using options 1 or 2 above). Use FabTime's "Width" and "Height" controls to change the chart size from inside FabTime.

If you have any questions about this feature (or any other software-related issues), just use the Feedback form in the software.

Subscriber Discussion Forum

Issue 6.02 – WIP States

In response to last month's main article, **Professor J. E. Rooda** of the **Eindhoven University of Technology** sent us a copy of the following paper:

A. J. de Ron and J. E. Rooda, "Equipment Effectiveness: OEE Revisited," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 18, No. 1, 2005.

This paper revisits the concept of OEE as a metric for assessing tool performance. The authors note that OEE includes equipment independent conditions, such as lack of WIP. They feel that tool performance should be assessed based on the performance of the equipment itself, rather than on any environmental variables (such as lack of WIP, or blocking due to WIP not being able to move downstream). They propose a set of equipment states that separates out this equipment-dependent vs. equipment-independent status, and then use the sum of the

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equipment-dependent states as a basis for estimating effectiveness. The system effectiveness is thus only based on events that are caused by the equipment itself (and how the equipment is operated). The authors conclude that because this revised equipment effectiveness metric is independent of tool utilization, it is "a real equipment metric." This addresses one of FabTime's long concerns about OEE when applied to non-bottleneck tools (which are penalized for lack of WIP by the standard OEE calculations), and we think that it is a highly promising approach. To request a copy of the paper, contact Jennifer.Robinson@FabTime.com.

Frans Brouwers of Philips Semiconductors also wrote to us regarding WIP States. "I would like to comment on your proposal for WIP States. First of all, I agree that we need standardization on this subject. It is an important issue in manufacturing improvement. Second I would like to share a document with you. This document has been written for discussing future refinements to our reporting systems. The document describes that for each relevant issue, an identifier is linked to the lot. Each identifier can be in a specific state (including various substates). Specific events trigger (sub-)state changes. The timing of these state changes is logged.

We first look at three WIP types: No WIP, WIP, and Closed. Within each of these we have life cycle states and substates. The No WIP type has the single life cycle "Created", with no substates. We break in process WIP into two life cycle categories: "Operational WIP" and "Stored WIP". Operational WIP we break down further into two substates: Progress and StandStill. In StandStill the lot makes no progress. This includes HOLDs, Rework, extra measurements, engineering actions, etc. Stored WIP we also break into two substates: Hibernated and WaferBank. For Closed WIP we look at two life cycle categories: Finished and Terminated. Finished WIP is broken into two substates: Complete and Incomplete (such as Engineering studies not requiring full processing). Terminated WIP is broken into three substates: Un-created, Scrapped, and Cancelled.

We further take the Progress and StandStill substates for Operational WIP and break those down according to Lot Activity States. Some of these activities are Tool ID linked, while others are not. Our proposed activities are shown below:

Tool-ID Linked Progress states:

- Selected (and batched)
- Loading Tool
- Internal Queue
- Load Processing
- Actual Processing
- Unload Processing
- Unload Queue
- Unload Tool
- Unbatched
- Wait for Transport

Non-Tool-ID Linked Progress States:

- Transport

The Non-Progress activities are not Tool-ID linked, and are broken into queue time and hold time states.

In the above, activities are always perceived from the lot point of view. From that perspective, transport to the next processing step is perceived as progress, as is rework, or other additional processing. The lot's perspective is that progress is happening to it. From the life cycle (state) perspective, the lot has come to a standstill. But that is not described in the activity states. The activity states are designed to be capable of handling tools with internal storage area. In such storage area lots might be stored for a prolonged time.

Transport Notes: It can be argued that transport time should not be split from queue time. The decision to split transport from queue time is based on the decision

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to base the design on the perspective of the lot. For the lot there is a huge difference between being in transport, and being in a queue. From the lot's perspective, while in transport, there is no interest in the actual queue size or in the idleness of the tool.

Queue Time Notes: In theory it is possible to break up queue time in various states based on:

- The position in the queue (first in priority, or not)
- The equipment state (idle, processing, down)
- Reasons for leaving equipments idle (like arrival of speed lots, or the near starts of planned maintenance)

However, in trying to design a state model, it becomes apparent that there is no practical solution. The basic problem comes from the fact that lots are not in queue for one tool, but for a group of tools. Some complications are the following:

- Each equipment has its own state. There is no overall equipment state.
- The priority sequence of lots differs from tool to tool. They depend on the state of the individual tools, on the recipes available, on the current setup of the tool, etc.

So breaking down the queue state becomes an unsolvable n-dimensional problem.

Hold Notes: While in Hold, some lots need investigation. So in fact, during a HOLD it should be possible to perform some process steps (including Queues and Transport). Although not all Shop Floor Control systems allow this, a universal state diagram should be capable of handling this option. When holds are perceived like this, they should be treated just like Rework. So a HOLD is a "StandStill" in the life cycle state in which non-standard processing is possible. Additionally a lot can have an activity state "Hold"."

FabTime Response: Frans' proposal for WIP states is more detailed than what FabTime proposed in the last newsletter issue, particularly in the activity states related to particular tool IDs. This proposal also uses more levels of hierarchy than we did (looking first at whether a lot is active or closed, and then whether an active lot is operational or stored, and then whether an operational lot is progressing or at a standstill, etc.) While there is certainly value to having this type of structured hierarchy of information, FabTime's goal was something simpler. Our aim was to look at a single lot's history, and break the time into a few easily identifiable states. Our states are consistent with the states described by Frans, except that (as described below), we treat travel time as non-value-added, and we do believe that it is necessary to distinguish between processing on rework and non-rework steps. We do agree with Frans that breaking up the queue time into various sub-states is probably not practical. We also think that the notion of breaking down "Stored WIP" (what we called "Crib") into two sub-states (Hibernated and WaferBank) makes sense, as it distinguishes between lots that are placed on extended hold while still in process and lots that are essentially completed.

Another **anonymous subscriber** wrote: "About the WIP states topic, in my fab we also apply the same approach but with more in-depth tracking of the tool's internal mechanisms. By following this approach we saw huge improvements, particularly in increasing the throughput of our bottleneck machine."

Issue 6.02 – Improving Lot Tracking in Less Automated Fabs

Alison Waters of National Semiconductor's UK fab submitted the following in response to last month's question about improving lot tracking in less automated fabs. "**Belinda Graham** and I have been working on this topic for

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the last few months. Our WIP transportation, delivery and storage systems are entirely manual. We use WorkStream dispatching to order lots at a process step and the operators are asked to run to that order using an electronic front end to select, download and process the batches. The Dispatch Lot Implementation System is known as DLIS within National Semiconductor. Recently we introduced a plant metric to monitor compliance to DLIS.

The main issue for the operators has been locating the batches identified by DLIS. Basic timing studies have shown that this batch location time can vary from 30 seconds to 5 minutes when there is no smart system to assist. Another issue we have is that when a batch is moved out of a process step, WorkStream automatically moves it into the next process step. This causes the lot to be placed on the next operation DLIS. This in turn causes problems for the next operator as the batch may be at the top of their DLIS, but not yet be physically with them. Hence time is wasted searching in vain for a lot that is still in transit. The solution we have arrived at is that when the lot is automatically moved out it is placed at the bottom of the next DLIS until it is either scanned and a rack location attached or 30 minutes have elapsed. In the latter case we need to highlight that it is overdue and put it to its rightful position within DLIS. This highlights to the operator that they should contact the previous operation as the batch should be running by now.

We discussed all of the available options. There are many possibilities with automation. However, these were not within our available budget, and are of course more future investment/expansion orientated. In the end we have implemented a bar coded scanning system on our WIP racks, each rack being a unique entity within the fab with bar coded locations marked off for each batch placed in the rack. The operator delivering the work scans the lot and the location on the rack where they are putting the lot. This location is displayed on the DLIS screen, thus telling the operator exactly where to find the required lot. A side benefit of this is that we only display the lot if it has actually been scanned in - no more wild goose chases looking for batches that have not yet been delivered.

We are considering changing our manufacturing system such that the move from the previous operation only occurs when the batch is scanned into the next WIP rack. However, we have not yet gone down this route. Another benefit to the bar code system is that we now have data that we will use to analyse things like frequency of delivery and operator attach time involved."

FabTime Response: We appreciate National Semiconductor UK's contribution of their experience on this topic, and hope that it will inspire other fabs to share their experiences, too. Clearly, having a lot tracking system to help locate lots precisely within the fab has the potential to lead to significant improvements in dispatch list compliance.

Issue 6.02 – WIP Utilization % (Subscriber Discussion Forum)

Mathias Duemmler of Infineon Technologies wrote in response to a question introduced by Douwe van Engen about WIP Utilization %. Douwe had stated the following regarding WIP Utilization %: "The only negative point I see is that there is no direct control of the excess of downtime." Mathias said: "I am wondering whether Douwe's question was more pointing towards the problem that when focusing on "WIP Util. %" as the only metric, one might lose the overview of equipment downtimes. To compensate for this, one might introduce a similar metric like "WIP/Tool Availability %". This indicator will be 100% if, whenever there is WIP available at a tool, the tool is "up". If, however, there are periods of

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time when there is WIP waiting for the tool, but the tool is down (for scheduled or unscheduled maintenance), the indicator will be less than 100%. This would be a measure of how well tool availability and WIP availability are synchronized. This indicator could be used, for example, to indicate whether preventive maintenance activities are scheduled during periods of no WIP. Furthermore, it might be a more meaningful indicator of tool availability than just the uptime percentage. High downtimes during periods of no WIP don't really hurt (in the case of non-bottleneck tools, for example)."

FabTime Response: We think that Mathias makes an excellent suggestion! We plan to explore this idea further in a future newsletter issue, and would welcome feedback from other subscribers. Has anyone used a metric like this?

A WIP-Centered View: Overall WIP Effectiveness

Introduction

As we discussed last month, a common approach in monitoring fab performance is to take a tool-centered approach. This involves measuring overall equipment effectiveness (OEE) for bottlenecks, recording A20 and A80 and downtime characteristics, and tracking the time that tools spend in particular states (especially the dreaded "standby with WIP waiting" state). The tool centered view is very important in running a fab, because the individual tools are so expensive.

In this two-part article, however, we propose a parallel WIP-centered view of the fab. That is, for an individual lot, we look at the time that the lot spends in various states (processing, waiting, traveling, etc.), and these are analogous to tool states. We also use the WIP state information to calculate a performance measure parallel to OEE, called Overall WIP Effectiveness. We believe that understanding exactly where lots are spending their time is an important step in improving cycle time, and that WIP states and overall WIP effectiveness have the potential to add a great deal to the understanding of the fab.

In Part I (last month's issue) we defined and discuss standardized WIP states. In this article (Part II) we will define the performance measure Overall WIP Effectiveness. Overall WIP Effectiveness (OWE) measures that percentage of time that a lot spends in a "value-added" state, out of the total time that the lot spends in the fab.

Recap: WIP States

The six basic WIP states that we proposed last month were:

- Processing
- In Queue
- On Hold
- Post-Processing (e.g. waiting for unload)
- Traveling
- In Crib (extended hold, or storage near the end of the line)

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We also noted that it might be useful to break down the Processing Time category into regular process time for a lot vs. time spent by the lot either being reworked or waiting for a rework child. Similarly, we said that it might be necessary to break process time into required process time vs. process time caused by speed losses.

Overall WIP Effectiveness

To measure Overall WIP Effectiveness, we need to break down the above states into value-added vs. non-value-added. Clearly, time in queue, time on hold, and time waiting to unload are not value-added for the lot.

Travel time is somewhat more controversial. Some travel time is needed to process the lot. However, no actual improvement is made to the lot during the travel time, and cycle time would be improved by shrinking the travel time. Therefore, for the purposes of this metric, we will consider travel time to be non-value-added.

Time in crib (extended hold, or storage near the end of the line), is similarly not value-added (and in fact increases the risk of obsolescence for the lot). The only time that value is really being added to the lot, then is during non-rework process time. Even then, some question may arise about the value-added nature of inspection steps. However, we believe that some amount of inspection does improve the quality of the resulting lots. Therefore, we will treat the inspection steps as part of process time for our calculations.

Thus, all of the time that the lot spends in the fab, with the exception of non-rework process time, is non-value added time, and our formulas for Overall WIP Effectiveness are as follows:

1. For a lot, history to date:

OWE = 100% * Total non-rework theoretical process time / Total cycle time

2. For an area (e.g. etch) for one shift:

OWE = 100% * Total relevant non-rework theoretical process time / Total relevant cycle time

Formula 2 is calculated by considering all lots that visited the area (etch) at any time during the shift, whether or not the lots were processed within the shift. For each of these lots, total relevant cycle time is the time within the shift that the lot was the responsibility of the area. For example, in a 6am to 6pm shift, if lot A arrives to etch at noon and stays in etch past the end of the shift, total relevant cycle time within the shift is 6 hours. However, if lot A arrives to etch at noon, is processed and leaves etch at 2pm, then total relevant cycle time is 2 hours. Total relevant cycle time for etch is the sum of total relevant cycle time for each individual lot that visited etch any time during the shift. Similarly, total relevant non-rework theoretical process time is the sum of theoretical process times for lots processed in etch within the shift, truncated at shift boundaries. E.g. a theoretical process time that continues past the end of the shift is only counted up to the end of the shift.

Formula 2 may be applied to days or weeks rather than shifts – simply truncate process times and cycle times at the day or week boundaries. Formula 2 may also be applied to other levels in the fab hierarchy, e.g. a toolgroup, by considering only the lots that visited the toolgroup within the shift. It can also be rolled up to the entire fab, in which case all lots would be considered.

Comparison to Existing Metrics

OWE offers a nice parallel interpretation, when compared to Overall Equipment Effectiveness (OEE). We maximize OEE (for a tool) by dedicating the factory to keeping the tool running good wafers at top speed. We maximize OWE (for a lot) by dedicating the factory to keeping the lot running at 1 X theoretical, with no delays. Neither is a perfect measure for the entire factory, but both tell you something useful. For OWE, a low value tells you that a lot

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spent most of its time in some non-value-added state. Conversely a high value (near 1.0) tells you that the lot spent most of its time in the fab actually being processed on tools at or near its theoretically best processing rate.

OWE is very close to being the inverse of the traditional cycle time x-factor for a lot. Cycle time x-factor, as defined in earlier issues of this newsletter, is total cycle time for a shipped lot, divided by theoretical cycle time for the lot. The difference when calculating OWE is that rather than comparing the total cycle time to some theoretical number, we look at the actual history of the time that the lot has spent in the fab. This is something that we can do largely by keeping track of WIP states for the lot, and will tend to be more accurate than comparisons to some manually maintained theoretical cycle time value.

Similarly, OWE is something like the inverse of Dynamic X-factor. As discussed back in issues 4.08 and 5.03, Dynamic X-factor (DXF) looks at the total amount of WIP in the fab, and then divided by the WIP that is currently being processed on tools. Over time, DXF can be shown to be equal to the average cycle time x-factor for lots exiting the fab. However, DXF is a fab-level metric. It can be scaled down to areas, but is not designed to give information about individual lots. Overall WIP Effectiveness is a lot-level metric. Also, DXF is a point-in-time estimate, so any changes that occur between observations are lost. OWE is a cumulative metric – it captures performance over time.

WIP states and OWE (formula 1) highlight lots with cycle time problems and provide a detailed analysis of historical cycle time losses. This information is a good starting point for cycle time improvement projects, e.g. reducing hold times.

WIP states and OWE (formula 2) provide a shift-level summary of cycle time performance and a view of current cycle time losses. This information is useful for trending, goal-setting, and comparison across shifts, to spot a problem as it develops.

Example

Graphical examples of Overall WIP Effectiveness are shown on the next page. The upper chart shows a comparison of OWE and WIP states for individual lots, with some WIP states (post-processing, crib) eliminated for clarity. The lower chart shows a trend of fab OWE and WIP states over several workweeks. Here again some WIP states (post-processing, crib) are eliminated for clarity.

Conclusions

By looking at cycle time losses, we can identify opportunities for improvement. In the first part of this two-part series we proposed a set of WIP States that apply to the time that each lot spends in the fab. That is, we proposed breaking up a lot's history, and measuring how much time it spends in several basic states such as queue, process, post-process, hold, transport, and crib. In this second part of the series, we drew on the WIP State data to calculate a single metric, Overall WIP Effectiveness. Overall WIP Effectiveness (OWE) measures value-added time (theoretical non-rework processing time) relative to total cycle time. OWE is similar to Overall Equipment Effectiveness, in that we maximize it by keeping lots moving, with no delays (much like we maximize OEE by keeping a tool running with no delays). Driving OWE up towards 100% will drive towards improved cycle time, through the reduction of non-value-added time. Understanding the WIP States that lie beneath OWE gives further insight into how to make this improvement.

Closing Questions for FabTime Subscribers

Do you look at the percentage of value-added time for lots? Do you measure cycle time x-factor for shipped lots? Do you think that Overall WIP Effectiveness adds

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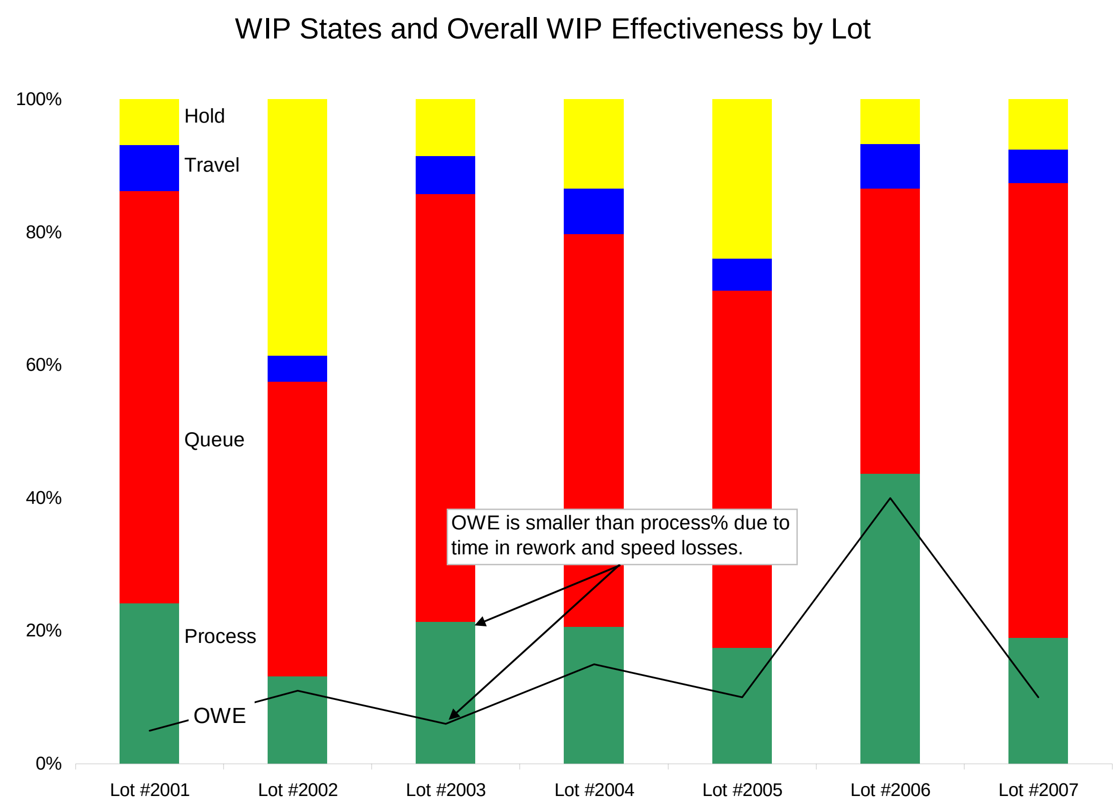

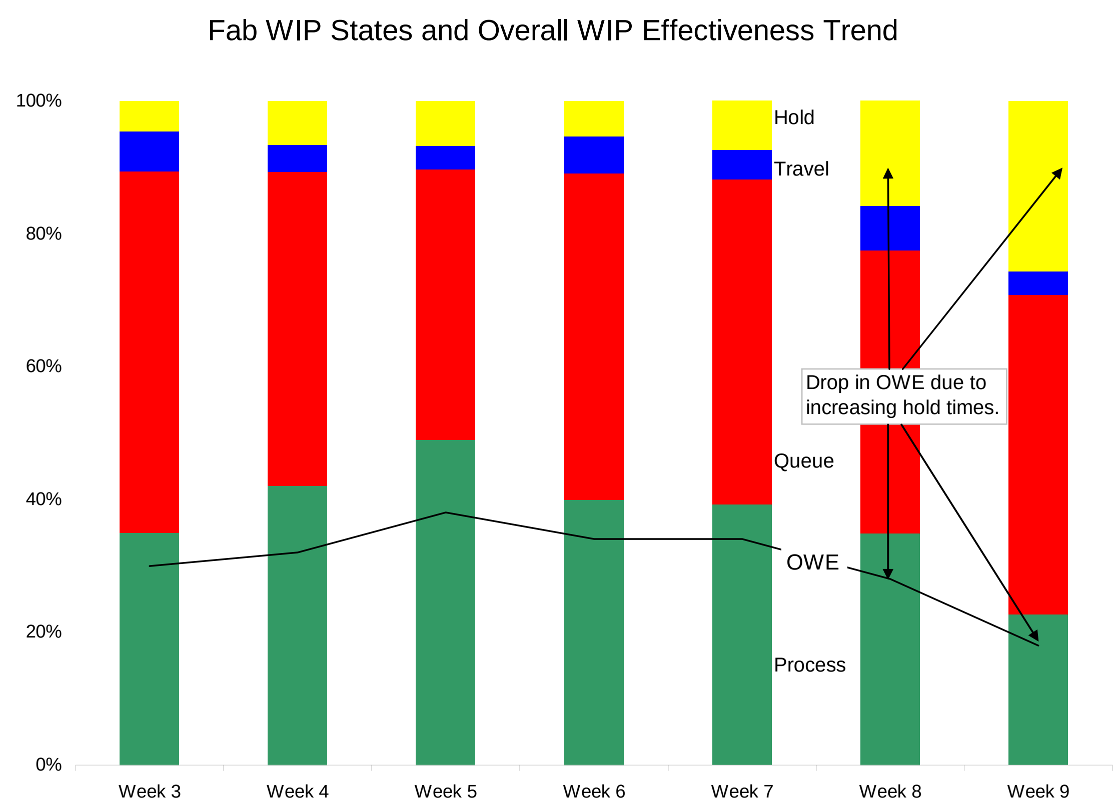

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useful information for driving cycle time improvement?

Further Reading

- J. Robinson and F. Chance, "FabTime Newsletter – Vol. 2, No. 4 – In-Depth Guide to OEE Resources," 2001.
- J. Robinson and F. Chance, "FabTime Newsletter – Vol. 3, No. 1 – OEE and Cycle Time," 2002.
- J. Robinson and F. Chance, "FabTime Newsletter – Vol. 4, No. 8 – Dynamic X-Factor," 2003.
- A. J. de Ron and J. E. Rooda, "Equipment Effectiveness: OEE Revisited," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 18, No. 1, 2005.
- SEMI E10-0699, "Standard for Definition and Measurement of Equipment Reliability, Availability, and Maintainability," SEMI, 1986.

Subscriber List

Total number of subscribers: 1794, from 420 companies and universities. 25 consultants.

Top 10 subscribing companies:

- Intel Corporation (93)
- Analog Devices (78)
- Infineon Technologies (56)
- STMicroelectronics (54)
- Freescale Semiconductor (51)
- Micron Technology (47)
- Philips (47)
- Texas Instruments (41)
- AMD/Spansion (37)
- Seagate Technology (36)

Top 5 subscribing universities:

- Virginia Tech (10)
- Arizona State University (8)
- Nanyang Technological University (6)
- University of California – Berkeley (6)
- Georgia Tech (5)

New companies and universities this month:

- Airfoil Technologies
- Noel Technologies
- Sparton Electronics

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.

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Do you need to answer questions like:

- Given a target product mix, do we need any new tools?
- Given the tools that we have, and the products that we are running, how many wafers can we expect to produce?
- Given our existing set of products and tools, what happens if the product mix changes? Where can we expect bottlenecks?

Are you tired of maintaining a standalone capacity planning spreadsheet?

FabTime's capacity planning module leverages the data already stored in the FabTime digital dashboard software, to make it easier to build capacity planning scenarios. The only required manual inputs are:

- Weekly ships per product.
- Product line yield percentages.

FabTime uses route information from the fab MES and calculates UPH data (tool speed) based on actual performance. FabTime also uses tool uptime performance to estimate availability (though this can be overridden). These inputs are used to generate predicted utilization percentages for each capacity type. Detailed intermediate calculations (UPH, tool productive time, tool rework percentage, etc.) are also available (an example for one tool is shown below). All outputs can be easily exported to Excel.

Capacity Planning Module Benefits

- Eliminate the need to maintain offline capacity planning models.
- Automatically update capacity planning data to reflect new conditions (process flows, tool uptime characteristics).
- Quickly run scenarios to anticipate (and avoid) bottlenecks caused by product mix changes.

C Type	Output	Value	Notes
1XStep	Rework Moves/Week	21	2004-09-06 10:00:00 to 2004-11-15 10:00:00
1XStep	Total Moves/Week	12310	2004-09-06 10:00:00 to 2004-11-15 10:00:00
1XStep	Rework Ratio	0	Rework Ratio = Rework Moves / Total Moves.
1XStep	Productive%	61	2004-09-06 10:00:00 to 2004-11-15 10:00:00
1XStep	Availability%	76.26	Availability = Productive% + Standby%.
1XStep	Historic Utilization%	79.99	Utilization (Mfg efficiency) = Productive% / Availability%.
1XStep	Productive(Rework)%	0.1	Productive(Rework)=Productive% * ReworkRatio.
1XStep	Net Availability%	76.15	Net availability% = Availability% - Productive(Rework)%.
1XStep	Arrivals (Units/Hour)	79.36	Based on total plan WGR=2025
1XStep	Tool Quantity	8	1XStep#1 ... 1XStep#8
1XStep	UPH	15.02	UPH = (TotalMoves/ToolQty) / (Productive% * 168)
1XStep	Required Hours/Day	126.84	Required hours = 24 * HourlyArrivalRate / UPH
1XStep	Predicted Utilization%	86.75	Util = 100 * ReqdHours / (24 * NetAvail * ToolQty / 100)
1XStep	Max WGR	2334.22	MaxWGR = PlanWGR / PredictedUtilization
1XStep	Historic WGR	2457.8	(Non Rework Moves) / (OperationCount / ProductCount).

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