# FabTime Cycle Time Management Newsletter

Volume 5, No. 9 October 2004

## 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 version (6.2) include color-coding of WIP lot list charts (to indicate on hold vs. in queue vs. in process) and reverse cumulative WIP data by process stage (to quickly locate shipment pull-points).

**Editor:** Jennifer Robinson

**Contributors:** Bob Kotcher (MMC Technology); Della Killeen (STMicroelectronics)

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## Welcome

Welcome to Volume 5, Number 9 of the FabTime Cycle Time Management Newsletter! This month we have an announcement related to past issue abstracts (to make it easier for you to find references to topics previously discussed in the newsletter). Our software user tip of the month is about generating a list of hot lots. We also have subscriber discussion related to 300mm cycle times (in response to last month's issue) and paperless cleanrooms.

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

If you find this newsletter useful, we hope that you will consider forwarding it colleagues who you think might enjoy it. If you get this newsletter through forwarding, we hope that you will consider subscribing for yourself. There is no charge to subscribe and receive the current issue each month. The next newsletter issue will be sent out in early December, after the U.S. Thanksgiving holiday.

Thanks for reading!—Jennifer

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# Community News/Announcements

### Abstracts of Past Newsletter Issues

One of the FabTime newsletter subscribers wrote to us recently, commenting that he had all of the past newsletter issues, but was having difficulty in finding issues related to particular topics. We thought that we would take this opportunity to point out to all of our subscribers that our website contains a full set of newsletter abstracts. Each abstract includes a brief summary of the main article from that issue, as well as a short paragraph listing the subscriber discussion topics. The abstracts are grouped by year, with all of the abstracts from a single year of publication displayed on the same page. This makes it relatively easy to search for particular topics. You can access these abstracts from the newsletter subscription page, at www.FabTime.com/newsletter.shtml, by either clicking on the "View newsletter abstracts" link the left-hand pane, or by clicking on any issue title from the list at the bottom of the page.

Currently these past issues are only available to customers of FabTime's web-based digital dashboard software or our cycle time management course. For our software customers, all of the past issues are available in HTML from the Help table of contents inside the software in the new version (currently being installed). We hope that others will still find the abstracts useful.

### Dynamic X-Factor Presentation

Several people asked us if there was a paper associated with our upcoming talk on Dynamic X-Factor (announced last month) at the ISMI Symposium on Manufacturing Effectiveness (to be held next week in Austin, TX). That conference does not include formal papers (just presentations). However, we talked about DXF in newsletter issues 4.8 and 5.3. If you would like a copy of the presentation from the ISMI conference (not a formal paper), email Jennifer.Robinson-@FabTime.com to request it.

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

# FabTime User Tip of the Month

### Generate a List of Hot Lots

Generating a list of hot lots (or, very similarly, a list of all lots on hold) is simply a matter of selecting the right set of filters on the WIP lot list. To do this:

1. Go to the Chart list, Show WIP Charts (towards the middle of the list), and click the Go button beside WIIP Lot List.

2. In the set of filters to the left of the chart look about 2/3 of the way down for the filter labeled "Prio:". Enter the priority codes for all of the types of hot lots of interest (separated by commas).

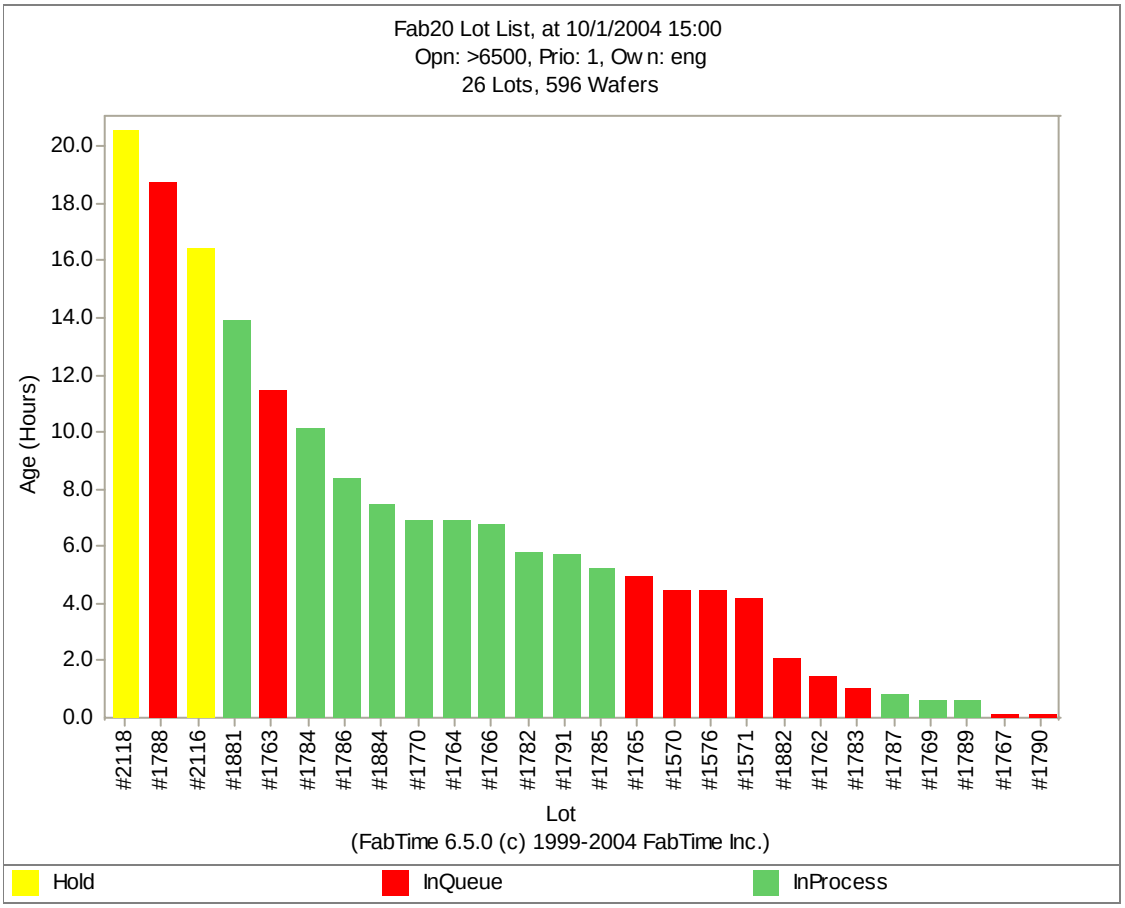
3. If you are not sure what priority codes are being used, clicking on the gray "Prio:" link next to the filter will display a list of all

of the values that FabTime sees in your MES (e.g. 0100, 0110, etc.). Use your Back button to get back to the WIP Lot List chart. (Alternatively, look at the Shipped Lot Cycle Time Pareto chart for a few weeks, sliced by Priority, and that will show you the priority codes most commonly in use at your site.)

4. Once you have the priority codes entered, enter any other filters that you normally use for WIP (e.g. filter by owner for manufacturing and engineering, etc.), and then press the Go button below the filters.

FabTime will display a list of all of the hot lots in the fab (which match your filters above), with the height of each bar showing the time that the hot lot has been waiting at its current operation. The new version of FabTime (in onsite testing right now) will use red, green, and yellow to indicate whether these lots are in queue (red), in process (green) or on hold (yellow). An example is shown below (containing data from a simulation model – not from an actual fab). In either version, if you only want to see the hot lots that are in queue, find the "Que:" drop-down at the very bottom of the filter list, and select "In Queue". Or, if you only want to see the hot lots that are on hold, find the "Hold" drop-down and select "On Hold". Press the Go button below to update the list.

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

## 300mm Cycle Times

**Bob Kotcher (MMC Technology)** wrote in response to Issue 5.07: "Though I'm not in fabs any more, I'm still reading your newsletter and still getting useful tidbits of information that can help me in our disk factory. Thanks for your continued great work on it.

I would like to offer a possible cause of moves being lower in 300-mm fabs. In a couple of places in your newsletter it was mentioned that perhaps 300-mm fabs more often have linked tools than 200-mm fabs. Though linking tools reduces cycle time, WIP, and labor between them to zero, does it not also, all else being equal, reduce capacity (which translates to higher cycle times, all else being equal)?

For example, picture ten tracks and ten steppers, unlinked, where any track can feed any stepper. If, at a point in time, two tracks and two steppers are down, our throughput is 20% below optimum. If, however, each track is linked with a stepper, and tracks 1 and 2 are down along with steppers 3 and 4, we now have four pairs of tools idle so we're down 40% in throughput. That is, uptime goes down because each tool is "down" not only for its own downs but also for its mate's downs. If loading on these tools did not change, this reduced capacity would translate to longer queue time in front of the linked machines, right? (I bet this is what you were referring to when you mentioned "reliability issues in the presence of increasingly linked toolsets.") It would be interesting to see any papers or simulation-model results which looked at the pros/cons of linking tools, especially as to whether overall cycle time decreases or actually increases. I acknowledge that even if linking machines does not help (or actually hurts) cycle time, it still offers other benefits such as labor reduction, elimination of misroutings between the operations, space savings, etc.

I'm interested in hearing what you and your readers have to say about this. Thanks for discussing this fascinating subject, which I think will be applicable to our disk factory, where I'm mulling pros/cons of linking some production operations (without the benefit of a simulation model…yet)."

## Paperless Cleanrooms - New Survey Question

**Della Killeen of STMicroelectronics** wrote: "I am trying to better understand how other wafer fabs handle the issue of paper inside cleanrooms. I think there is a human efficiency element to this issue, apart from the obvious defectivity side. Therefore, I'd like to ask your subscribers the following series of questions:

1. Do you have a 100% paperless cleanroom?

2. Do you allow printers only in chases, connected to Fab tools?

3. Do you allow printers inside the Fab?

4. What paperless solutions has your site deployed for taking notes and/or obtaining wafer maps?"

**FabTime Response:** We don't have much of a feel for this, but if people submit responses to FabTime, we'll be happy to compile them, and publish the results in the next issue. In your message, please indicate whether or not you would like your specific results kept confidential. Depending on the number of responses that we get, we may publish people's detailed comments (with permission), or simply provide some summary statistics.

# Analyzing Capacity Using MES Data

## Introduction

FabTime is in the business of taking data from the fab manufacturing execution system (MES), and using it to provide relevant information to the people who manage wafer fabs. To that end, we offer web-based digital dashboard software that displays real-time performance indicators related to cycle time, activities, tool status, and other metrics. The software also stores quite a bit of historical data concerning these metrics. Recently, we have been working with our customers to use this MES data to help plan capacity. Our goal is to leverage the data that we already store in the software, to make it much easier to build capacity planning scenarios. With improved capacity planning, we seek to anticipate (and avoid) bottlenecks and their associated cycle time penalties.

In this article, we present a quick overview of different capacity planning methods. We describe our approach to building MES data-driven capacity models, and cover the benefits and drawbacks of such models. We invite your feedback and discussion on this topic.

## What is Capacity Planning?

Capacity planning is the process of answering questions such as the following:

1. Given a target product mix (with process flows and yield rates), how many tools do I need of each type of tool?

2. Given the tools that I have, and the products that I'm running, how many wafers can I expect to produce? What is the largest number of wafers that I can product?

3. Given my existing set of products and tools, what happens if the product mix changes? Where can I expect bottlenecks?

Question 1 is primarily applicable for new fabs, or fabs that are ramping and adding tools. This question might be asked a year or more in advance, due to the lead times required for purchasing tools. It is a difficult question to answer, because process flows and tool performance values are often based on preliminary estimates. Naturally, those estimates are likely to change over time. Questions 2 and 3 are asked much more frequently, in some cases on a weekly basis. Planners addressing them do have the advantage of having more actual data available. However, maintaining this actual data in a format that allows quick generation of planning scenarios is non-trivial. The spectrum of capacity models is discussed below.

## Methods for Planning Wafer Fab Capacity

People in fabs today plan capacity today via a wide range of methods. Broadly classified, these can be broken down into static models and dynamic models. Static models range in ease of use and include:

- Spreadsheets
- Database models
- Analytic models (queueing models, linear programming models, etc).

Static models use a fixed set of inputs, and perform mathematical calculations to generate a fixed set of outputs. Static models do sometimes incorporate variability assumptions (e.g. queueing models). However, they are usually based on average values, and they generate a single predicted long-term value for each variable, for each time period analyzed.

Dynamic models, by contrast, look at a variety of possible outcomes. The primary dynamic modeling tool used for capacity planning is discrete event simulation. With a simulation model, assumptions are made about the possible distribution of variables such as equipment downtime. A sequence

of possible outcomes is then projected forward in time, to estimate one potential pattern of longer-term behavior. Several possible sequences are usually simulated (using different random numbers to select from the distributions), and then the results are averaged across the different simulation runs.

Static models are generally easier to use, validate, and debug than dynamic models. Although primarily useful for looking at static outputs such as tool utilization and move rate values, they can also give limited estimates of cycle time performance. For example, our Characteristic Curve Generator spreadsheet tool (available for download from www.FabTime.com-/charcurve.shtml) uses queueing formulas to estimate cycle times for a single toolset, at different utilization values. However, queueing models like this can only give long-term estimates of behavior, rather than details such as cycle time estimates for individual lots. Queueing formulas also are less applicable when modeling highly complex behavior, such as time constraints between process steps, and the interaction between batch and per-lot tools.

Simulation models can look at any time period of interest, and any level of detail required. Their primary drawback is that they require a considerable amount of work to build and maintain. And in a wafer fab, this issue of model maintenance is non-trivial. There is usually a lot of data (many operations, products, and tools), and it changes almost constantly. We know of sites that use simulation for ongoing fab analysis and capacity planning, and they have invested considerable effort in distributing and automating the model-building process. We have also talked with a number of people who have attempted to use simulation models for fab capacity planning, only to see those modeling efforts abandoned over time. This abandonment is due to the difficulty of keeping a large scale fab model up-to-date. Simulation models also can be harder to interpret than static models, because the outcomes encompass a range of potential behavior, rather than a single value.

There are tools that incorporate both static and dynamic elements, such as the Factory Explorer capacity analysis and simulation tool, distributed by Wright Williams and Kelly (and originally developed by our own Frank Chance). Other hybrid products, including in-house systems, also exist. However, these tools still require data maintenance, unless they automate the process of building models from existing data sources. Even a relatively simple spreadsheet based capacity planning model requires near daily maintenance in order to be useful.

## Eliminating the Model Building Effort

What we would really like to do is completely take away the need to build and maintain capacity models. In a perfect world, the capacity model would be a direct off-shoot of the MES, always automatically containing the latest data, and containing everything that we need to do analysis. This would make the capacity model easy to use, and make it easy to get up and running quickly on any given analysis. Our focus has been on taking the data that we already store in FabTime and using it to perform a series of static capacity calculations. We lose some of the advantages of dynamic models by doing this (simulated cycle times, etc), but it has the huge advantage that the calculations are very easy to understand, validate, and debug. And very little data is maintained manually.

What do you really need to perform a capacity analysis? You need process flows, in particular the required type of tool at each operation. Then you need to know the product mix (including both start rates and yield rates). With a UPH estimate you can estimate the required hours of process time per tool type. You then need actual tool quantities and tool uptime estimates, to determine how much time is available

from each tool type. Then you divide the available time into the required time, to see where you stand in terms of utilization.

Most of these pieces of information can be pulled or calculated from MES data, or are easy to input as a high-level scenario. Looking first at the tool availability information, the first thing that we need is to define the groupings that we plan to use for the capacity analysis. These may be the default MES toolgroups, but they may also include some hybrid groups that contain similar, but non-identical tools. In FabTime, we've defined a separate attribute called CapacityType. Each individual tool can only belong to one CapacityType. Yes, this is a limitation, because in reality there might be overlapping CapacityTypes (e.g. this operation can be performed by tool A or tool B, but this operation can only be performed by tool A). However, we've elected to make this trade-off in granularity, at least for now, for the sake of simplifying the calculations.

For each scenario, we select a historical time frame to use for tool performance estimates (e.g. 8-12 weeks). We then use actual data to estimate the average productive time and standby time (as a percentage) for each CapacityType (averaged across each of the individual tools within the CapacityType) during that time period. This gives us the availability percentage for the CapacityType (productive % + standby %). We then adjust this to subtract off productive time that was time actually spent processing rework wafers. We do this by calculating an actual rework ratio, which consists of rework moves divided by total moves (during the same time period). We then multiply the rework ratio by the productive %, and subtract the result from the availability, to obtain a rework-adjusted availability value. Multiplying this net availability by the tool quantity, and then multiplying by 24, gives the available hours per day for that CapacityType.

Looking next at the required process time data, we have process flow information from the MES. This consists of a sequence of operations (or recipe IDs), with an assigned CapacityType for each operation. We require as inputs for each scenario a weekly shipment rate and an expected line yield for each product. Using this information, we estimate the hourly arrival rate to each operation, and then sum across each CapacityType. We then estimate an average UPH rate for each CapacityType, using historical data over the same time period defined above. That is, we look at the total number of actual wafer moves, and the total amount of time that the tools spent in a productive state, and use those to calculate a historical average units per hour rate during the time that the tools were productive. From the daily arrival rate to the CapacityType and the UPH rate, we estimate the required process time per day for the CapacityType.

Finally, we divide the required hours per day for the CapacityType by the available hours per day, to get a predicted utilization value for this scenario. Where the predicted value is above 100%, this CapacityType may cause a problem, under the given scenario.

## But What About ...?

This methodology is certainly not perfect. For example, estimating the historical UPH rate based on actual moves is fine if you are looking at moderate changes. But if process flows are highly variable in terms of processes time per visit, the UPH value can vary significantly depending on the mix actually run during the historical data time frame. Assignment of a single capacity type to each operation may not be granular enough for some scenarios. Using historical data for estimating tool availability leaves you subject to fluctuations due to catastrophic downtime events, or annual maintenance.

However, we still think that as an extension to the capacity planning methods

available, this type of approach holds certain advantages. There is very little data that needs to be maintained outside of the MES (primarily the CapacityTypes, if these cannot be added to the MES directly). Once the CapacityTypes have been defined, running a new scenario based on any process flows that have been defined in the MES takes just a few minutes. The calculations are completely visible and easy to understand. If a tool is predicted to be over-utilized, it's straightforward to look at the historical UPH and uptime numbers, to see if they are reasonable.

And of course, if you don't like this method of estimating the UPH values from the MES data, you can certainly use different calculations. Calculate at the route-operation level, and then aggregate, for example. The point is that you have historical data that tells you how your tools have been performing, both in terms of availability and speed. If you can automate the process of using that data to plan capacity, you can save a lot of time, relative to standalone models.

## Extensions

Naturally, this type of methodology can be extended beyond straightforward calculations related to tool utilization. You can look at how data ramps over time. You can incorporate historical or planned cycle time values, and use them to predict shipment levels, or to determine the appropriate start rates to meet some shipment schedule.

We have also talked with people who tell us that they use procedures to export MES data into simulation models. This tends to not be quite as seamless as simply running static calculations, because more assumptions are needed to run a simulation model (dispatch rules, downtime distributions, etc.). Also, more analysis is required to interpret the results of a simulation. However, using short-term simulation in conjunction with MES data opens up all sorts of possibilities related to predicting lot completion dates and near-term cycle time performance.

## Conclusions

A wealth of useful data is stored in the MES, or can at least be calculated by starting with MES data. This includes process flows, wafer throughput rates, and tool availability values. In this article, we discuss taking some of this data, and using it to perform static capacity analysis calculations. While there are limitations to this approach relative to the level of detail that can be included in offline models, especially simulation models, we think that the time-savings make it worth considering. The primary benefit is reducing the need to maintain complex, offline capacity models, with data that changes rapidly over time. In our case, we have integrated the calculations in our FabTime software, so that users can enter scenarios based on product mix changes, and see the effect on predicted tool utilization values. We welcome your feedback.


## Acknowledgement

We would like to thank Tony Vu of Headway Technologies for working with us on the capacity planning methodology in FabTime.


## Closing Questions for FabTime Subscribers

Do you plan capacity using MES data? Do you extract MES data to load it into simulation models, or do you use it for static calculations? What do you think the strengths and shortcomings are of this method?

# Subscriber List

**Total number of subscribers:**, 1682 from 401 companies and universities. 25 consultants.

**Top 10 subscribing companies:**

- Intel Corporation (83)
- Analog Devices (79)
- Infineon Technologies (54)
- STMicroelectronics (52)
- Freescale Semiconductor (50)
- Micron Technology (43)
- Philips (43)
- Seagate Technology (38)
- Texas Instruments (38)
- AMD/Spansion (35)

**Top 4 subscribing universities:**

- Arizona State University (11)
- Virginia Tech (10)
- Technical University of Eindhoven (6)
- University of California – Berkeley (6)

**New companies and universities this month:**

- ATDF Inc.
- Cymbet Corp.
- ESCO LLC
- FASL LLC
- Filtronic
- GAL-EL
- Intense Ltd.
- ITC-IRST
- Technical University of Dresden
- University of Bath – UK

**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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# 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

$4950 plus travel expenses. On-site delivery for up to 15 participants, each additional participant $195. Discounts available for multiple sessions.

## Interested?

Contact FabTime for a quote.

FabTime Inc.
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Web: www.FabTime.com

## 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 is also available upon request.

## 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.

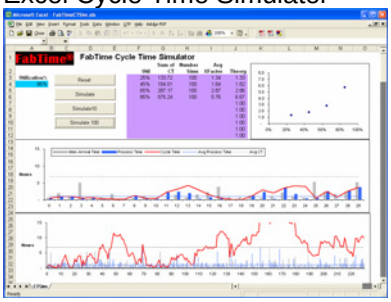
## Skills Gained

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

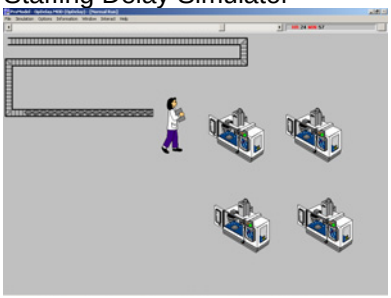
- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition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

## Sample Course Tools

Excel Cycle Time Simulator



Staffing Delay Simulator



## Additional Half-Day Modules

- Executive Management Session.
- Site-Specific Metrics Review.
- Capacity Planning Review and Benchmark.