Optimizing Staff Levels Using Linear Programming

Marino Arturo and Ariel Meyuhas

MAX I.E.G. LLC, 180 Old Tappan Rd, Old Tappan NJ 07675
Marino_Arturo@maxieg.com Ariel_Meyuhas@maxieg.com

ABSTRACT

This paper presents an overview of an approach MAX I.E.G. used to optimize the direct labor (DL) staffing level at a medium size semiconductor fab. This method used an activity-based staff model and queuing theory to minimize the staff level, and linear programming to optimize the cost per unit. Results included a 5% reduction in DL costs while maintaining or improving tool utilization.

INTRODUCTION

This paper details a project implemented by MAX I.E.G. for a 200 mm medium size North American fab in order to reduce DL cost while maintaining output and cycle time. The project implementation lasted eight months and made use of MAX experts along with the customer's industrial engineering team.

As the pressure from Asian foundries continues to increase, small- and medium-size fabs in North America face increased strain to reduce their cost per unit. Even though direct labor is an important cost component for most fabs, especially those in developed countries, there is very little effort to model the optimum staff level accurately. This situation has resulted in a wide range of tools per operator and tools per maintenance tech across different fabs (Figure 1). This variance holds true even for fabs with similar automation capabilities and tool age.

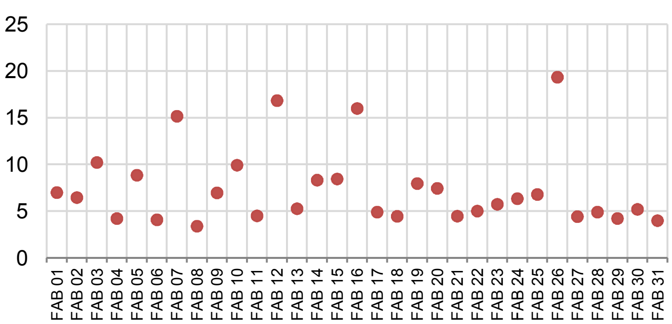

Figure 1: Number of Tools / Operator. MAX Data 2012.

This wide spread shows that there is ample room for improvement in many fabs, and it highlights the need for a method that is both accurate and easy to maintain.

MAX developed a model that integrates activity base modeling, queuing theory, and linear programming to optimize the staff level either to reduce cost or to guarantee tool utilization. The model was designed to be more accurate than the common approaches to staffing modeling, but at the same time easy to update in order to reduce the workload on the IE team.

COMMON STAFFING LEVEL METHODS

There are three common staffing level methods used in medium-size wafer fab: factoring, activity-based, and simulation.

Factoring uses tool to operator or tool to technician ratios and assumes that as the number of tools changes the number of operators and technicians required will change proportionally. This method works well in a very efficient factory for high-level estimates, but if the base ratio is not set correctly, it will carry all the inefficiencies with it. This model does not take into account the experience of the staff or the impact of production levels.

Activity-based models take into account the activities that are required from operators and technicians and calculate the number of heads required to fulfill those activities. Like the factoring method, this model usually does not take into account experience, and it cannot calculate the amount of tool idle time due to operator interference.

Simulation is the most complete and precise of the three models. Staffing simulation is usually attached to a production simulation model, its setup is complex, and it requires more resources than the previous models.

The MAX Activity-Based Model with Linear Programming (ABMLP) improves upon the ABM model providing higher accuracy but maintaining the ease of use and update of the original model (Figure 2).

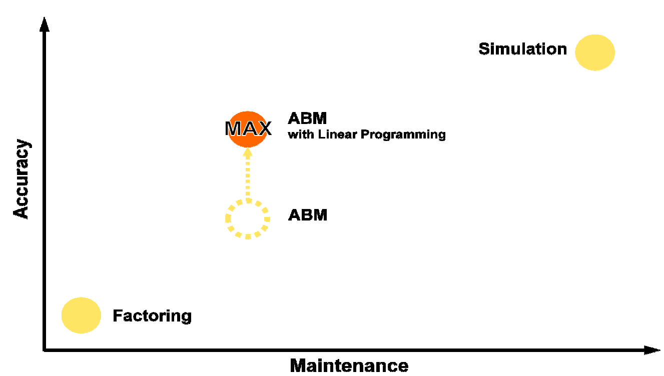

Figure 2. MAX ABM Accuracy vs. Maintenance.

PROCESS

The first step was to calculate the frequency of each activity that required operator or technician intervention based on its triggering mechanism. These breakdowns provide flexibility allowing for different scenarios like demand changes or tool install ramp.

After this frequency model was completed, the time available from operators and technicians was calculated and an experience rating was added to account for the impact of the learning curve.

All this information was entered in a queuing model that calculates the operator / technician interference and tools idle due to the lack of attendance. Then the optimum staffing level was calculated to achieve the desired utilization.

With this complete model, MAX worked with the finance team in order to calculate the optimum tool utilization level that would minimize the cost per unit.

ACTIVITY FREQUENCY

MAX, in conjunction with the fab personnel, developed a model that breaks down the activities for operators and technicians into three different categories, as follows:

Time-based activities: these activities are performed at regular or semi-regular intervals and are independent of the number of tools or the number of lots processed during that time interval. Common examples are shift passdowns, work area organizing () and staff meetings.

Tool-based activities: these activities are done on tool-by-tool basis, and are independent of the number of lots processed at each tool. They happen at regular or semi-regular intervals for each tool. Common examples are time-based preventative maintenance (PMs), tool area , and tool audits.

Lot-based activities: these activities depend on the number of lots being processed and may be independent of the number of tools used to process those lots. Common examples are lot load/unload, lot based PMs, material restock, and tool setups.

Some activities can fall in more than one category, for example a bath change in a sink that has to be done every 300 wafers or every 12 hours, whichever happens first.

STAFF AVAILABLE TIME

The time available from operators and technicians is calculated taking into account the following factors:

Breaks: time staff spends outside the fab due to breaks and lunchtime.

Vacation / Sick Days: time allocated to staff for vacation taking into account peak holiday periods and sick days based on historical data.

Staff Meetings: all meetings requiring the attendance of operators or technicians.

Training: training other than on-the-job training.

EXPERIENCE AND EFFICIENCY

Experience and efficiency are accounted for by creating a matrix with an efficiency score for each operator or technician at each activity.

Operators or technicians who perform an activity in the average time will be scored a one. Those with more experience who perform it in less time than the average will receive a proportionally higher score, and those who take longer to perform it will receive a proportionally lower score (Figure 3).

	Operator 1	Operator 2	Operator 3	Operator 4	Operator 5
Activity A	1.0	0.9	1.2	0.9	
Activity B	0.9	1.0	0.8	1.3	1.1
Activity C		0.9	0.8	1.0	1.2
Activity D		1.2		1.0	0.8
Activity E		0.9	1.2	0.5	1.1

Figure 3. Operator / Technician efficiency matrix.

INTERFERENCE MODEL

The data from the Frequency, Available Time, and Efficiency models is combined using queuing theory to calculate the optimum staff level required to maintain certain tool utilization level.

In this model operators and technicians act as the servers and the tools as the customers in queue (Figure 4). The time available is entered as the availability for each server and the times and efficiency ratings are used to calculate the service time.

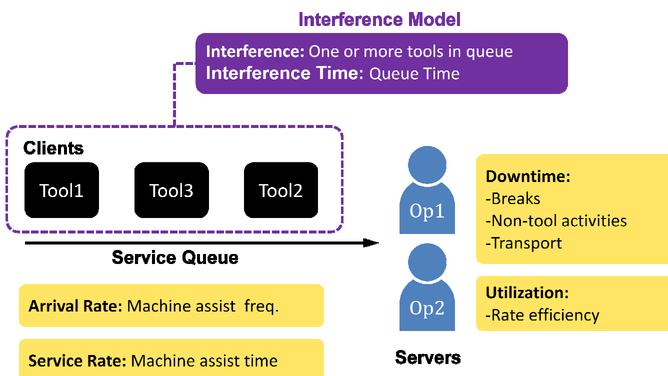

Figure 4. Interference Model with Staff as Servers and Tools as Customers.

The queue and service time then are modeled as idle time for the tools and the expected tool utilization calculated based on that number.

It is important that the optimum number of operators is calculated properly as overstaffing the area will cause a reduction in tool utilization. This reduction comes primarily from interference from operators who are idle due to overstaffing.

For non-bottleneck tool sets, it is recommended that the staff level is slightly below the optimum level, and for bottleneck tool sets is recommended that it is slightly above (Figure 5).

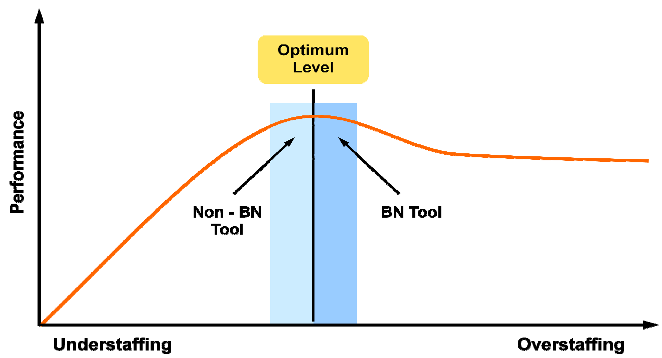

Figure 5. Tool Performance vs. Staffing Level.

COST PER UNIT OPTIMIZATION

In addition, to ensure that the tools have the required staff to maintain the desired utilization level the MAX team worked with the finance team to calculate the optimum utilization level to minimize the cost per unit.

A calculation of the staff required to obtain different utilization levels generated a curve that then it was overlapped with the cost per unit curve and the optimum point was obtained (Figure 6).

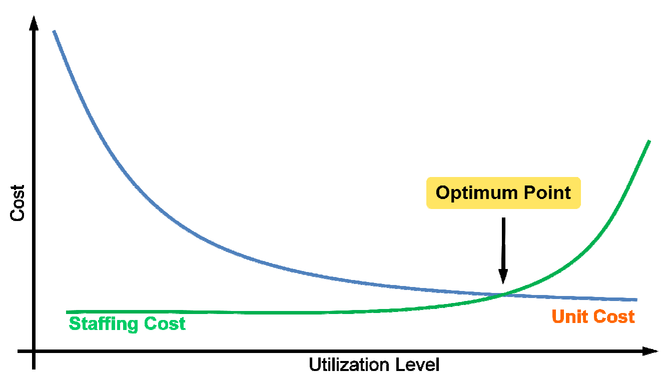

Figure 6. Cost Optimization Using Linear Programming.

This calculation provides the optimum cost from the staffing point of view, but it does not take into account intangible costs that may result from changes in cycle time or capacity flexibility loss.

RESULTS

At the end of the modeling phase, the understanding of operator and technician activities had improved significantly. The new information aided in the reduction of non-value-added activities and in the standardization of work methods among different areas and shifts.

The analysis of the work load for different operators resulted in the reallocation of certain activities which ensured a more even distribution of the work among all the employees, at the same time the activities were distributed in such a way that they would minimize the travel time for operators and technicians.

In addition, operators in the bottleneck areas or in areas nearby were trained in certain operations in order for them to keep the bottleneck running during peak periods.

An added benefit was that the efficiency matrix showed that even if operators were certified in certain activities, there were significant differences their skills. The certification and recertification processes were modified to ensure that the staff met certain performance level before certification and during recertification.

Overall, all this changes resulted in a 15% reduction in direct labor cost, while the tool utilization was maintained or improved in all areas.

CONCLUSION

The lack of an efficient staffing modeling approach has resulted in inefficiencies that are driving direct labor cost up. Tools are being under- or over-staffed reducing their utilization and causing interference with other operations.

A good staffing modeling will help to reduce direct labor cost, ensure tool utilization levels, and provide additional benefits like the creation of a data-driven training plan.