Global Cycle Time Reduction Methodologies

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Abstract

As cycle times become more critical across companies' supply chains, having a standardized methodology for reduction is critical to meeting customer demands and the desired goals. Today's business environment requires a systematic approach that can be applied globally. This paper discusses various approaches across different factories and provides examples of optimal solutions that have yielded successful results to reduce cycle time.

INTRODUCTION

As customer demands continue to increase and become more aggressive due to new products launches, it becomes critical to execute a unified cycle time (CT) reduction strategy. Due to the variation of products across a compound semiconductor manufacturer's supply chain, a global strategy must be applied. This paper discusses a high level structure to monitor cycle times in factories, as well as provides some methodologies for driving improvement.

STRATEGY

To ensure consistent execution across the entire company, the supply chain team has been made responsible for driving cycle time improvement across all factories globally. This includes internal fabs, assembly/test factories and all the raw material suppliers and subcontractors. The local industrial engineering teams partner with the supply chain organization to set up this structure.

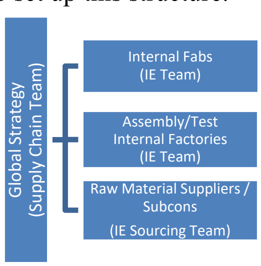


Figure 1: Global IE Infrastructure

Data is gathered locally to analyze past performance and that is weighed against the future requirements. A global CT expectation is set in each factory's top key performance indicators, and results are reported out on a weekly basis. Every industrial engineering manager from each site is responsible for coordinating efforts and reporting performance and progress. Best practices are shared across all teams in terms of strategies; standardize targets, formats and methodologies when possible.

Implementing common tracking systems for the whole organization has been very beneficial. It helps to identify opportunity areas and learn from other sites. It also ensures the metrics are consistent and accessible to all levels of the organization.

To ensure factories manufacturing different products can be fairly compared, internal factories have chosen to measure cycle time in terms of average and 95 percentile Days per Masking Layer (DPML). This metric normalizes each factory's cycle times for different technologies, as well as normalizes between factories making very different products. The supply chain team also uses this metric to compare supplier performance. In addition, two key metrics have been rolled out: the ratio of average to 95th cycle time and the X theoretical factor are used to drive improvement in external foundries as well as internal factories. Figures 2 and 3 illustrate examples of these.

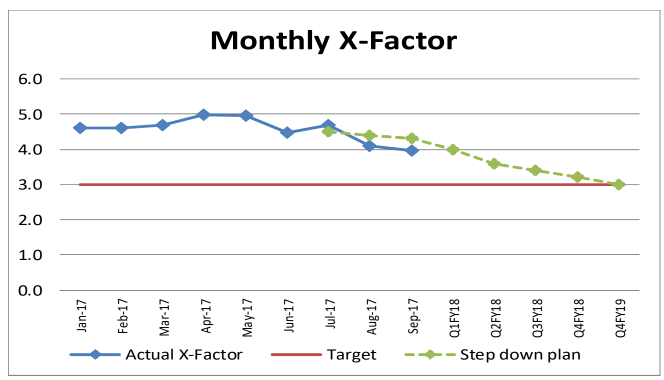


Figure 2: Monthly 1X theoretical X factor trend for a particular supply chain provider

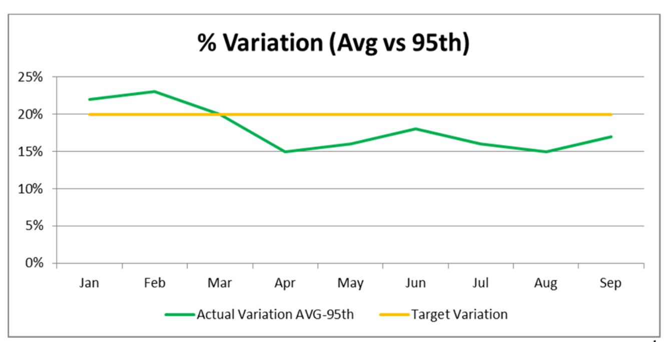


Figure 3: Monthly % variation between the average and the 95th percentile cycle time

For more clarification in our CT key metrics, the 95th percentile DPML is used to secure the delivery of 95% of the product within the committed lead time while the average helps to understand the overall performance and trend by total volume. Internal factories and suppliers are planned at 95th percentile. The reality is that the average is too risky since only 50% of the lots will be delivered on time, which is also why it is important to measure the variation between average and the 95th. Finally, the X-factor gives you an easy and quick understanding of the CT performance for any factory regardless their process and product. Put simply, it measures the actual CT performance against the perfect cycle time with no waiting times which is called 1X-theoretical. World class X-factor is <3X.

A critical factor in this strategy has been having top management involved and bought into having the CT metric as a top goal for the company. It is common to forget the importance or not recognize the benefit of having CT reduction strategies at the same level as other metrics like factory utilization and absorption. Without having a proper cycle time reduction program that is promoted by the leadership team, factories struggle with excessive number of priorities in the production line to cover for unexpected upsides in demand or planning issues.

EXECUTION

To hold factories accountable for meeting these metrics, the supply chain team holds a monthly review where each team reports out on their status. The following agenda is followed to ensure cycle time optimization:

1. Average and 95th percentile DPML for the previous month
2. Month by month WIP trend
3. Ratio of average to 95th cycle time
4. X theoretical factor
5. Paretos of cycle time drains
6. Step down plans
7. Details of the actions taken to reduce the cycle time

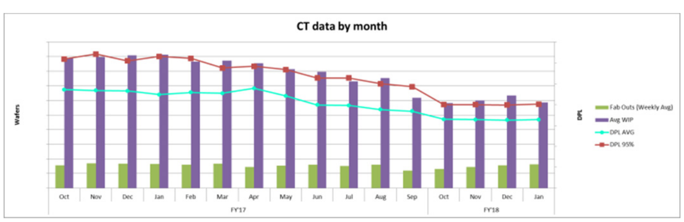


Figure 4: Cycle time and WIP trends. Short bars are Fab weekly average outputs, tall bars are average WIP, diamonds are average DPL, and squares are 95 percentile of DPL.

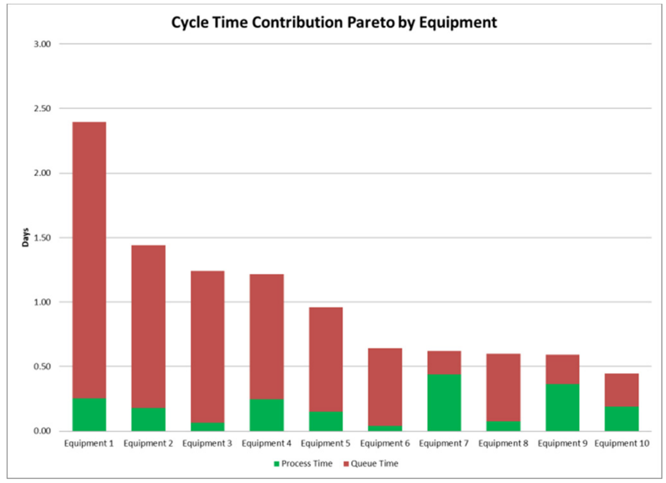


Figure 5: Pareto of cycle time drains. The top portion is queue time, and the bottom portion is process time.

In cases where the metrics are not being met, each team must present a step-down plan showing the specific actions they are taking to drive the cycle time down, the expected benefit in days reduced, owners, expected completion dates and status for each action. An example is shown in Figure 6. The respective factory representatives and their teams have to use their internal data to determine the benefit of their actions. Cycle time drain paretos are an effective method to determine where the focus should be, and also quantify the improvements. Sharing this information monthly across all sites not only helps to drive improvement by holding the factories accountable, but also allows cross-fertilization of ideas, which helps all factories to identify further areas of opportunity. Additional benefits of this practice have included the adoption of optimized systems or automation from the most efficient fabs in terms of data analysis

Current Avg CT	X
Target	Y = 0.84X

Identified Projects	Project Status	Project ECD	Completion Date	CT Benefit Full Effect Date	CT Benefit To take Full Effect	New CT (Days)	CT Delta to Target (Days)	Project Owner
Recalibrating OTD Standards		7/30/2017	7/30/2017	9/3/2017	Q4'17			S. Decker
Days ahead and behind visualization		7/31/2017	7/31/2017	9/4/2017	Q4'17			IE Dept
Z location promis enhancements		7/31/2017	8/30/2017	10/4/2017	Q4'17			IT
WIP Rack Improvement Team		11/1/2017		12/6/2017	Q1'18	.99X	.13X	IE Dept
Stepper Tiger Team		11/15/2017		12/20/2017	Q1'18	.93X	.09X	IE Dept
Lift off Tiger Team		11/15/2017		12/20/2017	Q1'18	.90X	.06X	IE Dept
Evap Tiger Team		11/15/2017		12/20/2017	Q1'18	.86X	.02X	IE Dept
WIP tracking (Wifi tracking)		12/1/2017		1/5/2018	Q1'18	.85X	.01X	IE Dept
RTD		1/31/2018		3/7/2018	Q2'18	.84X	0.0	IE Dept
Total						Y	0.0	

Figure 6: Sample step-down plan showing Cycle Time Reduction action plans for each factory.

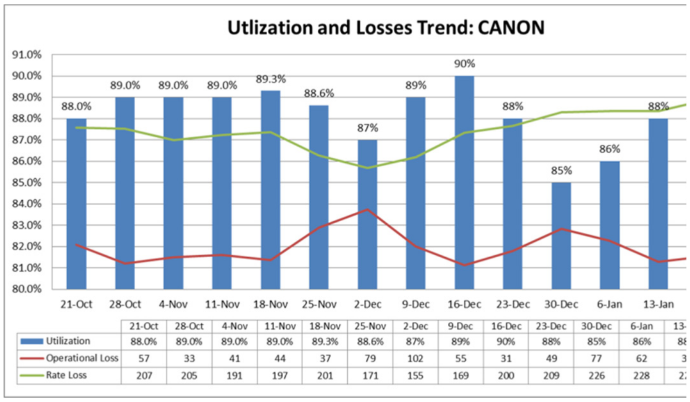
METHODOLOGY

To determine areas of opportunity, each factory's industrial engineering team works with production to identify the bottlenecks in the factory. The industrial engineering teams accomplish this by using the models developed through time motion studies and optimization methods such as linear programming. A cross-functional

Overall Equipment Effectiveness (OEE) team is then formed with industrial, process and equipment engineers as well as manufacturing. Charters are set for these teams with clear objectives of reducing the cycle time by increasing the capacity of these critical bottlenecks. The teams analyze data to determine where improvements can be made in terms of process speed, equipment availability (for both scheduled and unscheduled maintenance), and utilization. Utilization can be broken down further in terms of either operational loss or rate loss. Operational loss is defined as the missed opportunity to run production when equipment is available but is sitting idle. Rate loss is defined as any negative variance in process cycle time against the recorded standard in the capacity model. Action items are generated with owners and estimated completion dates, then summarized at a high level for the step-down plan.

EFFECTIVENESS

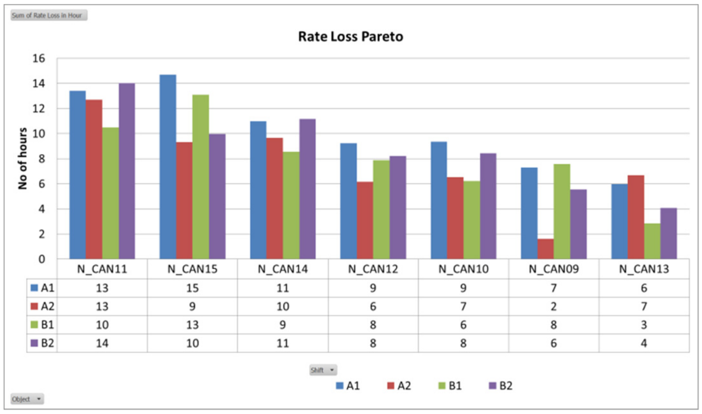
The following case study reflects a recent example of how this methodology was implemented successfully. In this example, the factory at hand was successfully meeting its cycle time goals. The demand and the mix were steady so there was no indication that the cycle time performance would be altered in a negative way. However, the cycle time started increasing after several weeks of output. The local IE team performed a cycle time pareto analysis similar to what was displayed in Figure 5. This data indicated that the factory's photolithography area, mainly the steppers, was performing at 8X its theoretical cycle time. Review of previous month's data showed that the cycle time alone at the steppers had increase by a factor of 250%. The IE team began their investigation by looking at the main factors that impact OEE (availability, utilization, speed or quality losses). By reviewing and breaking down utilization data in terms of rate and operational loss (see Figures 7 and 8), the IE team found its first clues.



	21-Oct	28-Oct	4-Nov	11-Nov	18-Nov	25-Nov	2-Dec	9-Dec	16-Dec	23-Dec	30-Dec	6-Jan	13-
Utilization	88.0%	89.0%	89.0%	89.0%	89.3%	88.6%	87%	89%	90%	88%	85%	86%	88
Operational Loss	57	33	41	44	37	79	102	55	31	49	77	62	3
Rate Loss	207	205	191	197	201	171	155	169	200	209	226	228	2

Figure 7: Utilization trend chart (bars). The top line is rate loss, and the bottom line is operational loss.

As seen in Figure 7, the last four weeks reflected an increase in rate loss which in turn was affecting the utilization significantly. The rate loss indicated that the uph (unit per hour) standards that were being used to calculate the utilization had decreased.



	N_CAN11	N_CAN15	N_CAN14	N_CAN12	N_CAN10	N_CAN09	N_CAN13
A1	13	15	11	9	9	7	6
A2	13	9	10	6	7	2	7
B1	10	13	9	8	6	8	3
B2	14	10	11	8	8	6	4

Figure 8: Rate loss comparison by tool

Further investigation highlighted that two tools were the biggest contributors to the loss in speed. With the team able to pinpoint the equipment to focus on, the next step was to observe the machines, analyze the run logs and alarm paretos and inquire if any parameters had been changed in the recipes that would affect the throughput. In this particular case, degradation of the tool components was the main contributor. The tools were not performing at the same speed as they had been and it was deemed that in order to maintain higher output, these components should be changed out more frequently for the benefit of throughput. By being able to identify the root cause of the issue, the queue time that had been accumulating in the photolithography area was brought back into control and the factory was able to meet the cycle time requirements again. Sharing of this information across all of the factories in the supply chain gave insight to all of the suppliers on how to handle similar situations and prevent them from occurring if possible.

CONCLUSION

By creating a company-wide structure for cycle time reduction, the organization has been able to successfully optimize and manage cycle times to ensure customer demand is consistently met.

ACRONYMS

CT:	Cycle time
DPML:	Days per masking layer
OEE:	Overall equipment effectiveness
WIP:	Work in process