Micron NUS-ISE Business Analytics Case Competition 2025 Question

NUS
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NUS ISE | industrial & systems engineering club

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Introduction

Micron Technology, a leading memory and storage solutions provider, has been strategically expanding its manufacturing capabilities to meet the growing demand. The company has developed a roadmap to address this future memory demand over the next decade by investing over $150 billion globally in manufacturing and R&D. This includes advancements in DRAM and NAND technologies, which are essential for various applications like AI, 5G Technology, and Data Centers.

Demand Dynamics

The demand for Micron's products is driven by several key factors:

- **Artificial Intelligence (AI)**: The rapid growth in AI applications, particularly in data centers, has significantly increased the demand for high-performance memory solutions.
- **5G Technology**: The expansion of 5G networks is boosting the need for advanced memory and storage solutions in smartphones and other connected devices.
- **Data Centers**: With the rise of cloud computing and big data, data centers require more robust and efficient memory solutions.

Background

<u>Market Trends</u>

Micron effectively manages the supply-demand balance by leveraging AI server demand and supply reductions to drive pricing improvements. The company has also seen increased interest from customers in securing long-term agreements due to expectations of tight supply and rising prices.

<u>Problem Statement</u>

Despite these positive trends, Micron faces several significant challenges which can be summarized into the following:

1. **Cyclical Demand**: The semiconductor industry is known for its cyclical demand, where periods of high demand can be followed by oversupply. This volatility affects Micron's revenue and profitability.

2. **Geopolitical Tensions**: Global political issues, such as trade restrictions and export controls, can impact Micron's operations and market access. These tensions can disrupt supply chains and affect the availability of critical materials.

3. **Intense Competition**: Micron competes with major players like Samsung, SK Hynix, and Western Digital. This competition requires continuous investment in research and development to stay ahead in terms of technology and innovation.

4. **Technological Advancements**: Rapid advancements in technology necessitate significant capital investment. Micron must continuously innovate to keep pace with emerging technologies like AI, IoT, and 5G, which drive demand for advanced memory solutions.

5. **Supply Chain Issues**: The semiconductor supply chain is complex and can be affected by various factors, including natural disasters, pandemics, and logistical challenges. Ensuring a stable supply chain is crucial for Micron's operations.

In this Business Analytics Case Competition, we will take a closer look into the elements of capacity planning based on the Total Addressable Market (TAM) to sustainably navigate the challenging environment especially the industry's cyclical nature, while maintaining the company's competitive edge and ensuring its profits are maximized.

Disclosure

For avoidance of doubt, all figures and numbers used in the questions provided are strictly arbitrary and have no reference whatsoever to Micron Technology, Inc.

Challenge

Question 1:

Part a)

Micron's executive team has determined an optimal business strategy to be executed from 2026 to 2027. During this period, the Total Addressable Market (TAM) for Micron for memory bits has been forecasted with a range and a fixed contribution margin per GB as detailed in Table 1. Micron produces different generations of products together at the Singapore Fab, which are currently labelled Node 1, Node 2 and Node 3. Each product has its GB per wafer and Yield information outlined in Table 2.

Table 1: Summary of TAM and Selling Price per GB from 2026 to 2027 (breakdown per quarter)

Quarter	Q1'26	Q2'26	Q3'26	Q4'26	Q1'27	Q2'27	Q3'27	Q4'27
TAM (±2 billion GBs)	21.8	27.4	34.9	39.0	44.7	51.5	52.5	53.5
Contribution margin per GB	$0.002	$0.002	$0.002	$0.002	$0.002	$0.002	$0.002	$0.002

Table 2: Summary of each product's GB per wafer and Yield

Quarter		Q1'26	Q2'26	Q3'26	Q4'26	Q1'27	Q2'27	Q3'27	Q4'27
Node 1	**GB per wafer**	100k	100k	100k	100k	100k	100k	100k	100k
	Yield	98%	98%	98%	98%	98%	98%	98%	98%
Node 2	**GB per wafer**	150k	150k	150k	150k	150k	150k	150k	150k
	Yield	60%	82%	95%	98%	98%	98%	98%	98%
Node 3	**GB per wafer**	270k	270k	270k	270k	270k	270k	270k	270k
	Yield	20%	25%	35%	50%	65%	85%	95%	98%

As an industrial engineer, you have been tasked by Micron's executive team to come up with a feasible product mix for the different generations that fulfills the business plan as summarized in Table 1. This consists of designing a loading (Table 3) that details the number of wafers that needs to be started each week for each product generation for each quarter.

Table 3: Loading profile of different product generations (Nodes 1, 2 and 3)

Quarter	Q1'26	Q2'26	Q3'26	Q4'26	Q1'27	Q2'27	Q3'27	Q4'27
Node 1	**12000**							
Node 2	**5000**							
Node 3	**1000**							

These are the constraints and assumptions to be satisfied when designing the loading:

1. Your designed loading needs to provide sufficient GB output to fulfill the TAM within the forecasted range. No additional GB should be produced per quarter which will lead to excess inventory and adversely impact the market price of each GB.
2. You are given Q1’26 loading as the initial condition.
3. Each node’s loading is independent and cannot deviate more than 2.5k wafers from each quarter to the next. For example, node 2 has 5k volume in Q1’26, so its Q2’26 volume cannot be beyond the range of 5±2.5k.
4. Loading volume cannot be negative.

Below are also the standard definitions and calculation methodologies to determine whether the business plan is met:

Attribute	**Definition**
TAM per quarter	The total number of GB output that meets the quality standard to be shipped to the customers to meet demand. TAM is provided as total GB needed for each quarter.
Quarter	Each quarter consist of **13** weeks, with each year having 4 quarters
Loading	Loading is planned on a weekly basis, it is the number of wafers to be started each week at the Fab. The loading will be constant throughout all weeks in a quarter. i.e. Loading of **5k** for node 2 in Q1’26 means we will start 5k node 2 wafers for each of the 13 weeks in Q1’26, in total 65k node 2 wafers will be produced in Q1’26.
GB per wafer	This is the designed number of GB each perfectly fabricated wafer contains (GBpW)
Yield	No wafer can be perfectly fabricated. This is the percentage of GB that is expected to be successfully fabricated out of the total designed GB amount. As fabrication process matures, yield will increase
GB output per quarter	The final GB amount that is successfully fabricated from the designed loading. It is calculated as follows for each quarter: $GB\ output\ =\ 13\cdot \sum_{node} Loading\cdot GBpW\cdot Yield$

Part b)

Once the loading is determined, you will need to design a tooling plan for the workstations to produce the required number of wafers. The capacity governing equation is shown in Equation 1 which provides the tool requirement for each product based on a given loading. This tool requirement can be translated to Capital Expenditure (CAPEX) required to support the designed loading. The CAPEX information for 10 different workstations and their Utilization/Minute Load/initial available tool count is summarized in Table 4.

Equation 1:

$$Tool\ Requirement = \sum_{node} \frac{Loading \cdot Minute\ Load}{7 \cdot 24 \cdot 60 \cdot Utilization}$$

Table 4: Summary of 10 different workstations and their metrics

Workstation	A	B	C	D	E	F	G	H	I	J
Initial tool count for Q1'26	10	18	5	11	15	2	23	3	4	1
Utilization	78%	76%	80%	80%	76%	80%	70%	85%	75%	60%
CAPEX per tool	\$3.0M	\$6.0M	\$2.2M	\$3.0M	\$3.5M	\$6.0M	\$2.1M	\$1.8M	\$3.0M	\$8.0M
Node 1 Minute Load	4.0	6.0	2.0	5.0	5.0		12.0	2.1		
Node 2 Minute Load	4.0	9.0	2.0	5.0	10.0	1.8			6.0	
Node 3 Minute Load	4.0	15.0	5.4			5.8	16.0			2.1

(i) Use the loading profile in (a) to determine the tool requirement for each quarter.

(ii) Use the tool requirement calculated in (bi) to provide a quarterly breakdown of the total CAPEX incurred from additional tool purchase.

(iii) Calculate the net profit based on the selling price per GB in Table 1.

(iv) With reference from (bi) to (biii), determine if this is the best loading profile to maximize profits. You can consider adjusting the loading profile in (a) and tooling plan in (b).

Assumptions to be considered:

1. For each node's wafer to be produced, they need to run through all workstations that has non-zero minute load for that node. For example, node 3 need to run through workstations A, B, C, F, G, J and thus contribute to their tool requirement.
2. You can assume that tool requirement for each workstation is independent and only governed by Equation 1 and nothing else. All other considerations such as transport time

between workstations, queueing time, tool idle time, process sequence etc. are negligible or already captured under a variable in Equation 1.

a. For example, workstation G’s requirement in Q1’26 is: $\frac{12000*12+1000*16}{10080*0.7} = 22.66$, this is entirely independent of workstation H’s requirement: $\frac{12000*2.1}{10080*0.85} = 2.94$

3. Enough tools must be purchased to fully cover the tool requirement for each workstation. For example, if tool requirement is 3.08, 4 tools must be available for production. For workstations with multiple nodes, requirement for each node should be summed before the tool requirement is determined.
4. The initial available tool count at Q1’26 are fully paid for and will not incur any CAPEX.

Attribute	**Definition**
Tool Requirement	The numbers of tools required to produce the specified loading. While exact tool requirement can be a decimal, the final required tool count is an integer rounded up from the exact decimal.
RPT	Recipe Processing Time. This is the time in minutes that is required to complete the recipe that is uniquely associated to a step
Minute Load	The number of minutes a wafer needs to be processed at each workstation. This is the sum of all RPT of the steps running in the workstation.
Utilization	The percentage of time that a tool in a workstation can be used for production
CAPEX requirement	Calculated by multiplying required tool purchases with each workstation’s CAPEX per tool
Contribution margin	This is the selling price per GB minus the operating expense per GB, it represents the profit per GB sold before accounting for fixed CAPEX cost
Profit	$Profit = GB\ output \cdot Contribution\ margin\ per\ GB - Capex\ requiremen$

Part c)

In no more than 150 words, provide a justification on the choice of this loading.

Question 2:

In the previous question, the capacity governing equation assumes that the RPT is static. However, RPT varies from wafer-to-wafer in reality. This variability introduces some uncertainty into our capacity planning. Currently this static RPT number is assumed to be the **median** RPT of each step. Micron's executive team has tasked you to determine the risk associated with the plan when considering RPT variability and whether median is the best method to obtain an RPT value.

Part a)

To quantify the risk to your plan in Question 1, you will need to calculate the probability of not being able to fulfill the designed wafer output.

Scope of this study has been limited to workstations H, I, and J, running 1 step each for Nodes 1, 2, 3 respectively. A sample of their RPT has been collected and provided in the attached excel file.

Table 5: Workstation H, I, J's median RPT

Workstation	H	I	J
Initial tool count for Q1'26	3	4	1
Utilization	85%	75%	60%
Node 1 Median RPT	2.1		
Node 2 Median RPT		6.0	
Node 3 Median RPT			2.1

Assumptions to be considered:

1. The raw RPT data provided is a representative sample of the actual RPT distribution.
2. The actual RPT can be treated as a random distribution.
3. All wafers' RPT are independent of each other.
4. Not being able to meet the designed loading means the tool requirement of a particular week exceeds the tool available.
5. Designed wafer output is not met if any week in the planning horizon from Q1'26 to Q4'27 cannot meet the designed loading & loading of each week in a quarter cannot be varied.
6. Assume each week is 1 time block, you do not need to consider any other time blocks.
7. If no viable loading plan has been found in question 1, you can consider the probability of not meeting Q1'26's baseline loading plan only.

Table 6: Q1'26 loading plan & GB output

Quarter	Q1'26
Node 1	**12000**
Node 2	**5000**
Node 3	**1000**

Here are some guidelines to calculate the probability of not meeting your designed loading:

(i) As the RPT samples are representative, are you able to find the RPT's population mean and standard deviation?

(ii) What is the expected value for each RPT based on the population characteristic determined in (i)?

(iii) Governing equation of calculating tool requirement can be interpreted as the total time required to run the designed loading divided by the available tool time on a weekly basis.

$$Tool\ Requirement\ = \sum_{node} \frac{Loading \cdot Minute\ Load}{7 \cdot 24 \cdot 60 \cdot Utilization}$$

What is the expected tool requirement based on this?

(iv) However, expected value is still a static measure. How can we find the total time to process X number of wafers where each wafer's processing time is a random variable following the population characteristics determined in (ii)?

   a. Are you able to create a simulation for this or some analytical method?
   b. Can different types of populations use the same methodology?

(v) From assumption 4, not being able to meet design output of a week means our total processing time determined in (iv) is higher than total available tool time. What is the probability associated with this inequality?

(vi) As all weeks in a quarter have the same designed loading and tool available, are we able to use the answer in (v) to find the probability of at least 1 week in a quarter not meeting the designed loading?

(vii) After finding the answer to (vi) for all quarters, can we find the probability of at least 1 quarter not meeting the designed loading? This will give you the probability of not meeting your designed loading throughout the planning horizon.

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Part b)

Given your results in 2(a), discuss whether median is the best statistical measure for estimating RPT. If not, what do you propose is the best method to estimate RPT? Evaluate your proposed method against the current method of using the median.

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Part c)

How would your answer in Q1 change, given the new insights gained from 2(a) and 2(b)? Discuss the risks associated with RPT variability. You may use the pointers stated below as reference:

(i) Will the projected profits be impacted?
(ii) What risk level is acceptable?
(iii) How should you change the planned loading or tool purchase to reduce the risk?

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