**Micron NUS-ISE**

**Business Analytics Case Competition 2021**

**Question**

**(Pre-University)**

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Contents

[1. Introduction 2](#_Toc74258814)

[2. Background 3](#_Toc74258815)

[3. Disclosure 3](#_Toc74258816)

[4. Challenge 4](#_Toc74258817)

[Question 1 4](#_Toc74258818)

[Question 2 5](#_Toc74258819)

[5. Format of Submission 10](#_Toc74258820)

# Introduction

Digital technologies such as Smart Devices, Internet of Things (IOT) and Artificial Intelligence (AI) are changing the world we live in from the way we connect with each other, how we make purchases, and even how we commute. Data is the new currency, and it is all around us, in our connected devices, machines, and gadgets. It’s captured in data centers, stored in cloud, and surging through networks. 2.5 quintillion (1018) of data are stored, shared, and streamed per day. And memory chips are the key enablers in moving, processing, collecting, storing, and sharing data, empowering many of the cutting-edge digital devices we use today and the technologies that are changing our life.

Micron is a world leader in innovative memory solutions that transform how the world uses information to enrich life. Backed by 40 years of technology leadership, Micron offers the industry’s broadest and most cutting-edge technologies including DRAM, NAND and NOR memory, enabling disruptive trends in key market segments like mobile, data center, client, consumer, industrial, graphics, automotive, and networking. Micron has operations throughout Asia, Europe and the United States, with more than 40,000 team members collaborating with each other. Singapore is home to Micron’s largest manufacturing footprint with three fabrication facilities and a technology center supporting innovation across the company. Micron continues to expand its presence here, serving as the base of worldwide operations.

Graphical user interface, application

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Figure 1: Applications of Micron Memory Chip

# Background

According to World Semiconductor Trade Statistics, the Worldwide Semiconductor Market was up 6.8 percent in 2020, and is expected to show a double-digit growth of 10.9 percent in 2021[[[1]](#footnote-1)]. This increase in projection growth, combined with the worldwide shortage of semiconductor chips have encouraged many major semiconductor players to increase their capacity to meet this global demand.

Micron Semiconductor, as one of major suppliers of DRAM and NAND memory chips, have invested heavily in expanding its own capacity through acquiring new plant. On top of acquiring new plants, Micron Semiconductor have also expanded its existing plants, including a two-time expansion in Singapore in 2016 and 2019, and a recent expansion in Virginia in 2020.

With recent Covid-19 pandemic, the world faces an explosion of demand for an array of electronics such as automotive, smartphones and PCs. This brings about an unprecedented further surge in demand for chips used to make these electronics. With chips manufacturers being unable to keep up with the sudden increase in demand, the world is facing with a global supply shortage for chips.

Micron Semiconductor, being one of the largest chip manufacturers in the world, identified this as a perfect business opportunity to further ramp up its production. In this Business Analytics Case Competition, we will explore a bit more on the decisions and considerations that we can choose in order to increase production output.

# Disclosure

In this challenge, all figures and numbers used are strictly arbitrary and have no reference to Micron Technology, Inc.

# Challenge

Semiconductor memory market is projected to have a double-digit year-on-year growth to support all electronics device that we use daily. With the advent of 5G technology, memory demand is expected to increase further.

There are 2 main options for a company to fulfil its semiconductor demand: either outsource the production of semiconductor chip to other companies or build its own in-house capability to manufacture it.

Outsourcing the production of semiconductor may not necessarily move all production to the 3rd party, it may outsource only some parts of the manufacturing process or even certain processing stages. E.g., outsourcing final testing chip to 3rd party before assembly.

## Question 1

What are the factors that need to be considered by a company in deciding between outsourcing their manufacturing process or building their own fab? **(Write no more than 2000 words)**

## Question 2

For Micron Semiconductor, we decided to expand our own manufacturing capability to meet future demand instead of outsourcing to a 3rd party. Micron has 5 fabrication plants that produce NAND and DRAM, located in Singapore, Japan, Taiwan, and USA. Micron continuously invests in infrastructure to increase its output.

A semiconductor fabrication plant (commonly called a fab) is a plant where devices such as memory chips are manufactured. Turning sand into tiny devices with millions of components is an extraordinary feat of science and engineering and requires intimate knowledge of etching and wafer cleaning processes, ultra-pure water, photolithographic, chemical dispense, chemical slurry, life safety and toxic gas monitoring systems. Each fab operates a continuous production process, 24 hours a day. Each week, thousands of silicon wafers are processed using highly sophisticated production machines (refer to Dataset Excel tab ‘Machine Diagram’ & tab ‘WS Data’) in the cleanrooms and each individual wafer is sequentially processed in up to 200 steps (refer to Dataset Excel tab ‘Flow’)

Semiconductor fabrication is often regarded as a volume game as it must maintain a sufficiently large volume production to support high capital investment from acquiring leading-edge production machines and/or building state-of-the-art cleanrooms in the beginning. Apart from initial capital investment, additional time and money are also required to produce a chip from idea all the way to a fully qualified product. As such, committing to a move like starting a new fab or expanding existing fabs can be quite daunting.

The expansion of existing fabs may seem like the most attractive option as less capital investment would be required initially. However, an expansion of the existing fab would translate to a longer travelling time between machines and between the manufacturing steps as the distance between the machines increases. This relationship can be captured in the following equation:

Travelling time **exceeding 2 minutes** will cause the machine to idle. It is undesirable for the machines in the fab to not fully utilize its capability.

Below is the supplementary information that may help you in solving the question:

|  |  |
| --- | --- |
| **Attribute** | **Definition** |
| Utilization | Proportion of time which the machine is utilized to carry out manufacturing processes. |
| Load size | The number of wafers per chamber that can be loaded into a tool for the manufacturing step defined. |
| Raw Processing Time  (RPT) | The time taken for a tool to complete the defined manufacturing step in minutes. |
| RPT basis | The number of batches a machine can process at any point of time which is determined by the number of chambers a machine has. |
| Chamber count | Number of chambers in a machine |
| Machine availability | The proportion of time available for the machine to carry out manufacturing activities/processes. |
| Footprint | The physical size of the machine measured in terms of square feet. |
| Capacity | The capability of a machine to produce an output for a specific time. It is often expressed as a function of utilization, raw processing time and load size. |

Diagram

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Figure 2: Schematic diagram of a machine

Figure 2 illustrates an example of a schematic diagram of a machine. Depending on the machine’s configurations, a machine can have one or more chambers. Each chamber can work independently from each other to complete a defined manufacturing step. A load port is used to load the wafers into the machine for the chambers to do the processing. Wafers are transported between machines using a Front opening Unified Pod (FOUP) that can carry up to 25 wafers.

Currently, there is 1 fab. The current fab can produce a weekly output of 5,000 wafers and the space available in the cleanroom to house the machines measures at 50,000 square feet.

For every new fab built, the clean room space availability increases at the multiplication of 50,000 square feet.

The cost of constructing of new building varies due to its complexity. New building construction will require additional cost to build infrastructure to connect each building. Below is the estimation of cost from the construction team:

|  |  |
| --- | --- |
| **Cost of building construction in the same location** | **Cost of building** |
| 1st Building | $1,000,000,000 |
| 2nd Building | $1,070,000,000 |
| 3rd Building | $1,170,000,000 |
| 4th Building | $1,290,000,000 |

**Example:**

1. Scenario 1: Expand in original location (Build 2nd building).

Cost incurred: $1,070,000,000.

1. Scenario 2: Start a new plant in a different location.

Cost incurred: $1,000,000,000.

Part (a):

In Micron, the leadership team saw an opportunity to grow the business with the rising demand from electronics such as smartphones and the proliferation of applications like the Internet of Things, cloud computing and Artificial Intelligence.

**As the newly appointed Industrial Engineer, you are tasked to provide a data driven analysis for the leadership team to decide whether an expansion of the existing fab or starting up a brand-new plant elsewhere is the better option. Provide a data-driven recommendation to guide the leadership team in their decision making.**

Guiding Questions:

As guidance, this question will be broken down into a few parts to facilitate your thinking process.

* Q2.1 Formulate an equation to calculate the capacity per week of each machine based on relevant variables given.
* Q2.2 Determine the number of machines of each type that are required to produce the current wafer output of 5000. Based on the number of machines found, determine the capital investment (CAPEX) required to purchase the machines required to meet the current wafer output of 5000. ***(Enter your answers into the Answer sheet provided)***
* Q2.3 Assuming the wafer output as a variable, determine how changing the wafer output affects delivery time.
* Q2.4 Determine how changing the wafer output affects the footprint requirement.
* Q2.5 Calculate CAPEX requirement of machines and buildings as a function of wafer output.
* Q2.6 Based on assessment on Q2.3 to Q2.5, use a decision analysis method (e.g., decision tree) with delivery time and loading as factors to guide the leadership team on the decision of whether to expand an existing fab or build new a new fab.

Part (b)

Identify and explain other factors (other than delivery time and loading which are already considered in part a) that you think are critical for fabrication plant expansion. Assess if Micron Singapore is a good candidate for expansion.

Your challenge for Question 2 involves writing a report addressing parts (a) and (b). Your report should include a description of your method and assumptions made in the model formulation. There are many ways to approach this problem and you can use different approaches to answer part (a). You may use Excel, Programming script or any other relevant software to obtain solutions to the problem. Please consider any other interesting factors and/or scenarios in your analysis that you feel might be important in guiding your leadership team.

*Tip:* You can make simplifying assumptions with proper justifications.

Limit the report to a maximum of 15 single sided A4 pages, excluding cover page, references and appendices (if any). The font size used should be 12 in Times Roman font with 1.5 line spacing and pages should be numbered. For part (a), do fill in the necessary answers that you obtained in the excel sheet named “Answer Sheet” provided in the Zip folder.

Below is the supplementary information on certain terminologies that may help you in the understanding of the question:

|  |  |
| --- | --- |
| **Terminology** | **Definition** |
| 1. Delivery Time/Travelling Time | Time taken to transport FOUPs between machines. |
| 1. Loading | Wafer output of a fabrication plant. For example, loading of plant 1 = 500, loading of plant 2 = 500, total wafer output=1000. |
| 1. Fab/Building | A fabrication plant that houses machines to manufacture devices such as memory chips. |
| 1. CAPEX | Capital Investment |

# Format of Submission

Participants are to submit the following at the end of the competition.

|  |  |  |  |
| --- | --- | --- | --- |
| **File Type** | **Naming convention** | **To include:** | **Word Limit/Page Limit** |
| PDF | P\_GroupName\_Report1 | Question 1 Report | 2000 words |
| PDF | P\_GroupName\_Report2 | Question 2 Report | 15 pages |
| Excel Workbook (.xlsx) | P\_GroupName\_AnswerSheet | Answer Sheet | - |
| Any format | P\_GroupName\_Supporting\_Document | Supporting Documents for Question 2 part (a) | - |

**Note for Supporting Documents:**

You may submit your workings you have used to derive your answer for Question 2 part (a). This can be in the form of an Excel file/programming script or any other files.

**Submission of Documents:**

Zip the above documents and submit your answers in one zip folder. Name your Zip folder as **P\_*GroupName\_Answer.***

Submissions of the zip folder must be done by **18th June 2359 on *Micron NUS ISE BACC 2021 Case Question Submission Google Forms***. Late submissions will be subjected to penalties.

Submission link: <http://bit.ly/BACC21SUB>

THE END

1. [1] https://www.wsts.org/76/Recent-News-Release#:~:text=The%20Worldwide%20Semiconductor%20Market%20was,of%20the%20fourth%20quarter%202020 [↑](#footnote-ref-1)