EXECUTIVE SUMMARY

In this simulation, your team is entering the image sensor market. You will need to make decisions related to capital, product development, product manufacturing, marketing, and sales, assuming that you will be in this business for multiple years. The game will be played in multiple rounds; each round corresponds to a year.

Your Goal is to Capture Market Share and Hit Financial Targets

In each round, your team will compete to meet specific numerical goals. These goals vary from round to round, to reflect the success that a start-up business is expected to make over time. Your team's overall goal is to meet or exceed the numerical goals set for that round (as shown below). Teams that achieve all goals will be designated as Market Leaders and receive a score of 100. Other teams will earn designations and scores reflecting their levels of achievement. It is important to understand that the salability of your product depends on how your products compare with the competitors' products (in terms of quality, price, promotion, and place). You will not know the answer to this until the round ends—so it is full of ambiguity, just like the real business world.

Year	Market Share	Revenues	Gross Margins	Share Price	ROE	ROA
1	12.00%	$4.00M	52.50%	$2.00	--	--
2	14.00%	$8.00M	55.00%	$2.50	--	--
3	--	$12.00M	57.50%	--	7.50%	5.00%

You are Working As a Team And Will be Assigned A Role

At the beginning of each round, each team member will be assigned the role of a divisional head or the CEO. Each divisional head is responsible to post decisions pertaining to their division. While the submission is done individually by divisional heads, decisions should be discussed and evaluated collaboratively, as each division's decision will impact other decisions. It is also important to note that the CEO can post decisions related to all divisions, the CEO should not dominate the decisions; instead, the CEO is expected to strategize, forecast, coordinate, and collaborate.

You'll Need to Leverage Research Data to Better Your Odds of Success

The Business Case and the Customer Analysis are the key resources to help you make informed decisions in Round 1. Therefore before making decisions, it's in your best interest to conduct research and review The Business Case and the Customer Analysis. It's also highly recommended that you refer back to research data as you make decisions. The Business Case gives you a general overview of the simulation (industry, market, product, operations, marketing, and capital sources), and The Customer Analysis provides greater insights into the customers and their preferences.

Make & Post ALL Decisions Before Deadline

It's highly recommended that your team make decisions in the following order: **Product** → **Marketing** → **Operations** → **CEO Projections** → **Finance Decisions**. It's also required that your team POST ALL DECISIONS BEFORE THE ROUND DEADLINE. If decisions are not posted by the deadline, your team will likely perform poorly for that round.

Review & Analyze Results

After each round ends, you should review The Performance Feedback and Team Reports to gain a better understanding of your performance. The Performance Feedback report will provide personalized feedback. The Team Report will provide competitive analysis information. It compares your team's performance in relation to your competitors and provides insights to help your team make changes to do better in the next round.

THE OPPORTUNITY

Anna is a recent business graduate. She and three of her close friends were not ready to assume the role of "employee"; these five ambitious graduates wanted to pursue entrepreneurial aspirations first. The Z team, as they called themselves, included, Anna, Bob, William, and Teresa . One afternoon, as usual Anna was sitting at her favorite coffeeshop, combing through webpages, hoping to uncover a business opportunity. An article in the Daily Californian caught her eyes and attention. Filled with excitement, Anna jumped out of her seat, and dashed towards Bancroft way. She was eager to meet the rest of the Z team to share the exciting news.

Anna yelled, "Hey guys! I have some great news to tell you!" She pointed at a Daily Californian article and said, "we have a great opportunity in the image sensor business!"

Bob and William looked at each other in confusion, and William responded, "who cares about image sensors!?!" and returned to taking selfies.

Anna responded, "apparently, many do and there's an opportunity for us to capture value in this market. Shall we do some research and then make a decision?"

"Informed decisions are always good" Teresa responded with a wink.

THE ECONOMY

During this time, the U.S economy was still in its expansionary phase for more than 8 years, which was unusual. Some analysts suspected that the economic cycle would shift towards recession. However, conflicting data such as the low inflation rate suggested otherwise. To compound that, there was a new president with a new fiscal policy and with plans to nominate a new Federal Reserve Chairman. Therefore, the level of uncertainty with the Fed's monetary policy was high. It was unclear if the Fed would remain dovish.

THE INDUSTRY

The industry is driven heavily by demand from smartphone manufacturers, but is expected to expand further due to the growing demand from the automotive, healthcare, and surveillance space. Bob, Anna's friend, called his buddy Tom, an expert in the semiconductor industry.

Bob: "Hey Tom, this market is huge. How do we play in this game?"

Tom: "This game?? It's not a game, it's a billion dollar market."

Bob: "All markets are games to play. It's a competition right? With players? Rules? Uncertainty? Goals?"

Tom: "What's the goal?"

Bob: "Capturing market share of course!"

Tom: "Are you sure about that? Anyways, in this 'game', you have to pay to play."

Bob: "How much, a few million?"

Tom: "How about a billion dollars...and that's just to buy the facility and production line. High barriers to entry."

Bob: "I'm no longer enjoying this call Tom, speak to you later."

Digital image sensors are silicon microchips that are engineered to operate in different ways. The engineering involved in these circuits is very complex; so are the techniques used to manufacture these microchips. Integrated circuits are manufactured in semiconductor fabrication plants (commonly called fabs; sometimes foundry). The central part of a fab is a clean room, which is very expensive to build and maintain. Fabs also require very expensive equipment, and can easily cost hundreds of millions of dollars.

In addition to the high fab costs, constant new technologies create shorter product life cycles in this industry. Another challenge had been the low prices, especially in the case of mobile phone image sensors. Therefore, historically, the image sensor manufacturers had to be efficient, adapt to technological changes, and customer-

centric to make a profit. Image sensors required by the automobile industry require higher quality than the mobile phone industry, but those sensors are priced high and have higher profit margins.

THE MARKET

Even though William was not optimistic about the image sensor opportunity, he felt obliged to make an informed decision on behalf of his team, rather than simply rejecting it. Therefore he reached out to his cousin Emily, who is a senior equity research analyst at XYZ Investments. Without even realizing that Emily's specialization is in the semiconductor industry, he asked her about the market potential of the image sensors.

Emily: "I love this sector! An image sensor is such a tiny product, but the applications are enormous! Smartphone developers are the main buyers, but exponential growth is expected in the automobile, healthcare, and surveillance markets. Gross margins in the mobile segment are roughly ~35%, but the auto segment can be roughly 2x that. Why are you interested in image sensors?"

William: "My buddies and I are interested in a start-up gig, right? One of my buddies read this article and became interested in making image sensors. Honestly I know nothing about them, and I wasn't interested."

Emily: "There are major global players in healthcare and surveillance spaces and it will be hard for you to compete there. However from my analysis, a substantial unmet demand still exists in mobile phone and automobile sectors; since there aren't large dominant players your chances would be better in those two segments. Based on my calculations, there will be about ~7.66 million units of unmet demand next year from the mobile and auto markets. Here is some market information on the unmet demand and growth projections for the image sensor needs in the mobile and auto market segments (see Exhibit 1 below)."

EXHIBIT 1 - Unmet Demand & Growth Projections

Description	Mobile Segment	Auto Segment
Year 1 Annual unmet demand	5,836,592 units	1,820,000 units
Expected annual growth percentage		
Year 2	25%	35%
Year 3	25%	35%
Year 4	5%	25%
Year 5	10%	25%
Year 6	5%	10%
Year 7	5%	10%
Year 8	5%	5%
Year 9	5%	5%

At the end of the conversation, William's thoughts changed from pessimistic to cautiously optimistic. He was impatient to share this new information with his team.

Anna continued researching the image sensor market. The more she read, the more optimistic she became. While Bob got discouraged after his call with Tom, Anna and William convinced him to join a team meeting to discuss the image sensor opportunity further. William was able to convince Jose, his freshman year roommate, a materials science major who is now working for a silicon chip manufacturer, to join Team Z. Based on the initial chit-chat, it was clear to Anna that if the billion dollar facility cost that Tom mentioned is true, then there is no point in wasting time. Therefore, Anna asked Jose to share his thoughts on this.

Jose: "It will not be realistic for you to build a manufacturing facility from scratch. However, there are few companies that operated semiconductor fabs in multiple locations but ceased operations of some when they consolidated their operations. Those fabs already have the cleanrooms and other infrastructure that is needed. All you will have to do may be to lease a fab and buy the machines for the production lines. So, you will be looking at about one million dollars lease and another few millions for the production line costs. In other words, you will be looking at a few millions, instead of a billion."

With that, Anna noticed her team lightening up. She took a quick vote to see if the team wants to pursue the opportunity further. With everyone on board, Anna started talking about the next steps.

Anna: "Any suggestions on how we can get more information about customers?"

Jose: "Trade shows! All the players will be there; not just customers, all players.. You guys should attend the CES conference and tradeshow! It's coming soon! It's the most influential tech event in the world. There are about 170,000 people that attend each year. This includes customers who demand image like Apple and Tesla."

As Jose was speaking, Bob did a quick search, landed on the Consumer Technology Association, the organizer of the CES. He read outloud.

Bob: "CES is the global stage for innovation. This is where the world's biggest brands do business and meet new partners, and the sharpest innovators hit the stage"

Anna: "Sounds like a plan! If that's not a great place for customer discovery, I'm not sure what is."

CES Conference

The team agreed that Anna should attend CES held in Las Vegas. Determined to learn and network as much as possible Anna attended as many presentations and visited as many booths as possible. On the third day of the conference, while grabbing drinks at the hotel bar at the conference, Anna overheard a conversation around image sensors. She decided to join the conversation:

Anna: "I'm sorry, but I couldn't help but listen to you two complain about the image sensor market. What's to complain about? Seems like it's a great market to be in right now. Hi, my name is Anna."

Fred: "Hi I am Fred. I actually love the image sensor space. Our gripe is with corporate. There is so much more of the market we can capture, but corporate is not investing in capacity. This has impacted me personally because my compensation is heavily based on commissions. I earn 1.5% on all sales contracts."

Anna: "Can't you join a company that is willing to expand? Is 1.5% sales commission standard for this industry?"

Fred: "All the other players either have capacity constraints or are focused on other customer segments. But, to answer your other question, yes 1.5% commission is an industry standard for direct selling."

Anna: "Who are these customers that no one is serving right now?"

Fred: " You are asking a lot of questions. Well, I am planning to retire soon and I attended this year's conference for fun and to say my goodbyes. I have no ambitions to pursue. So, you caught me at the perfect time to ask these questions. These are mobile phone manufacturers and automobile manufacturers. In the image sensor world, we call them mobile customers and auto customers. Based on the information I have, there will be an unmet demand for 7.66M sensors next year, just in these two market segments. One more thing, all customers buy in December."

Anna: "How much are these customers willing to pay?"

Fred: "From $1 to $35— mobile (auto) customers in the lower (higher) end. The lower and upper prices that these two customer segments are willing to pay are very different. For example, no mobile customer will pay over $15.00 for an image sensor because that would be too expensive. At the same time, any sensor priced at or below $1.00 is probably too good to be true and therefore, they won't buy. Auto customers on the other hand, will not pay more than $40 for an image sensor, and they believe that any sensor sold for less than $5, is too good to be true. I have details on the minimum product features customers will accept and the prices that each customer is willing to pay (See customer analysis to the right)."

Customer	Round	Segment	Demand (in Units)	Lower Price Bound	Higher Price Bound	Minimum Resolution	Minimum Sensitivity	Minimum Power	Minimum Temperature
1	1	Auto	91,000	$5.00	$12.00	1	3	1	1
2	1	Auto	182,000	$12.00	$27.00	1	3	1	2
3	1	Auto	273,000	$12.00	$27.00	1	4	1	3
4	1	Auto	728,000	$12.00	$27.00	1	4	1	3
5	1	Auto	273,000	$12.00	$27.00	1	4	1	3
6	1	Auto	182,000	$12.00	$27.00	2	5	2	4
7	1	Auto	91,000	$27.00	$35.00	2	5	2	4
8	1	Mobile	291,829	$1.00	$5.00	3	1	2	1
9	1	Mobile	583,659	$2.00	$10.00	3	1	2	1
10	1	Mobile	875,488	$2.00	$10.00	4	1	3	1
11	1	Mobile	2,334,636	$2.00	$10.00	4	1	3	1
12	1	Mobile	875,488	$2.00	$10.00	4	1	3	1
13	1	Mobile	583,659	$2.00	$10.00	5	2	4	1
14	1	Mobile	291,829	$8.00	$12.00	5	2	4	1

Anna: "Oh wow!! This is a pretty detailed customer analysis; I like how you have identified the minimum product requirements of each customer."

Fred: "None of these customers are loyal. They always buy the highest quality product at the lowest price. Let me rephrase, mobile customers are more price sensitive and auto customers are more quality sensitive."

Anna: "How do you reach these customers?"

Fred: "Trade shows!!! CES is one of the best. Jon may be the best person to explain how to reach customers."

Jon: "Thanks for volunteering me Fred. Well, I am not planning to retire. However, since our company has customers to buy every single sensor that we are able to make, I don't mind sharing my secrets with a newcomer."

Anna: "Well thank you. I really appreciate it."

Jon: "We do direct selling to our larger customers that we meet through trade shows. Trade shows are where the magic happens. When we spend somewhere between $3M to $4M annually on trade shows, we make the most impact on generating product awareness. We tend to spend slightly more for the autonomous vehicle segment given that it's a bit newer. When we spend more than $4M in a given year, we aren't getting any additional value. It takes a few years of marketing to achieve the greatest market awareness."

Fred: "One last thing to note. It's a pain to sell directly to smaller customers. Honestly, most of them don't attend trade shows; so it is hard to connect with them directly. Therefore we tend to work with distributors to sell to customers with smaller demand. These tend to be the customers listed in our Customer Analysis Report with volume of 5% or less within a segment."

Jon: "We market to smaller customers through various online distribution channels. When we market online, we only need to spend a fraction of what we spend on trade shows, roughly one fifth."

Anna collected their business cards and quickly sent a message to the team summarizing the wealth of information she gathered. about potential partnerships and customers.

Based on the conversations she had with Fred and Jon, the importance of understanding the customers' product requirements is a key determinant of the success or failure of an image sensor manufacturer. While she understood the product features, she was not sure if Bob and William did. She thus summarized the product features as below.

THE PRODUCT

Image sensors are devices made from silicon chips that capture photons and convert the photons into electrons to display optical information (i.e. images). It is used in a variety of devices. Most notable are digital cameras and mobile phones. It is produced in a semiconductor Fabrication plant ("Fab" or "Fab Plant") from silicon wafers.

Silicon Wafer

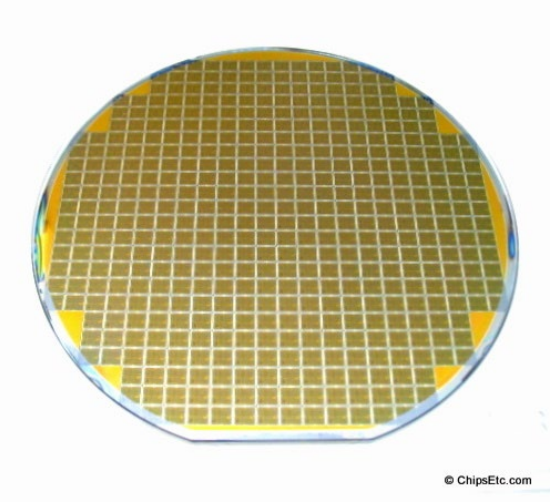
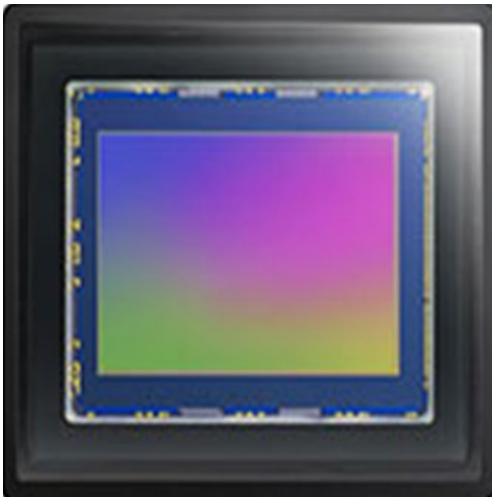


Image Sensor Chip



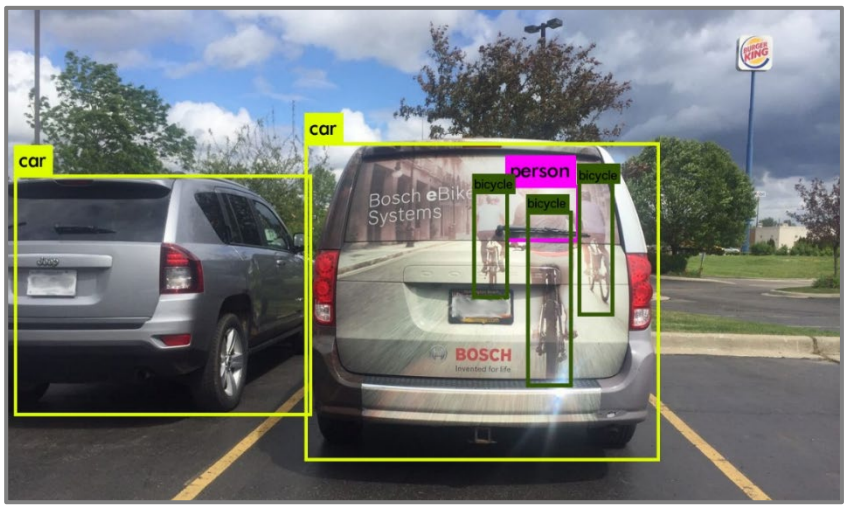
PRODUCT FEATURES

Resolution

Resolution is the fineness of details in an image. High resolution sensors are small sensors with high pixel count, which means the pixel has to be smaller. The smaller the pixels, the higher the resolution (the finer the details you can capture in an image). Mobile customers want image sensors with high resolution because: 1) smartphones need small sensors; and 2) smartphone customers want high resolution pictures. For auto customers, having a high resolution is not that important as fine details of the image is not as important as image detection.

Sensitivity

Light sensitivity is a measure of the minimum amount of light needed to generate an electronic signal. Reducing pixel sizes (increasing the resolution), reduces light sensitivity, which has consequences both for high and low levels of scene luminance and for short and long exposure duration. For Auto image sensors, this increases safety risks. For example, when driving in fog or darkness, an image sensor with low light sensitivity might not be able to detect objects correctly. See picture to the right:



The downsides are, when the light sensitivity is high (larger sensor with larger pixel sizes), that resolution and power consumption suffer. These are not negative factors for mobile sensors.

Power

Power refers to the power efficiency of the sensor (the higher the power consumption, the lower the power efficiency). Power consumption of the sensor impacts the battery life of a mobile phone. Therefore the mobile customers require power efficient image sensors. On the other hand, power efficiency is not a critical product feature for auto customers.

Temperature Range

Temperature range measures a sensor's ability to perform in extreme temperatures, which is an essential feature for auto sensors. This is a minor factor for mobile sensors as smartphones are not exposed to extreme temperatures in the way that vehicles are.

Product Feature Ranking System

Image sensor industry (in the sim only) uses a standard ranking system to communicate the product features. Each feature is ranked from 1 to 10. 1 being the lowest and 10 being the highest. Customers use the ranking system to express their minimum product requirements (in terms of resolution, sensitivity, power, and temperature in that order). For example, if a customer specifies their minimum product requirements as 1, 4, 6, 8, then that customer's image sensor requires a chip that has a low resolution, moderate light sensitivity efficiency and a very high power and temperature tolerance. Based on the customer segment information, this customer is likely an auto manufacturer. If an image sensor manufacturer intends to sell to this customer, its image sensor should at least meet the 1,4,6,8 requirement.

Product Features, Development Time, and Research and Development (R&D) Cost

Another impact of the product development time is, it impacts the product release date. For example, if your product release date is July 1, then you can't start production until that date. As a result, your production volumes will only be 50% of the annual capacity.

Exhibit 2 (see below) provides the expected research and development cost at different quality levels, including different ranks for each product feature.

THE OPERATIONS

Jose with his materials science degree and experience in semiconductor manufacturing understood the science and technical details behind the manufacturing process. Through his industry connections, he was also able to narrow down a handful of idling fabs. After intense negotiations, the team was able to secure a fab for $1M.

EXHIBIT 2 - Estimated R&D Costs

Rank	Resolution type	Sensitivity type	Power type	Temperature type
1	$176,400	$441,000	$176,400	$441,000
2	$375,318	$938,298	$375,318	$938,298
3	$438,654	$1,096,638	$438,654	$1,096,638
4	$501,990	$1,254,972	$501,990	$1,254,972
5	$628,662	$1,571,652	$628,662	$1,571,652
6	$882,000	$2,205,000	$882,000	$2,205,000
7	$1,323,000	$3,528,000	$1,411,200	$3,528,000
8	$2,116,800	$6,350,400	$2,540,160	$6,350,400
9	$3,598,560	$12,700,800	$5,080,320	$12,700,800
10	$7,916,832	$27,941,760	$11,176,704	$27,941,760

In order to start operations, Team Z needs to purchase production lines. Jose worked closely with Bob, who's degree is in industrial engineering, to explore production line options. They identified four options. Each product line has an estimated useful life of eight years. Just like every other semiconductor fab, this fab is expected to operate 24/7; therefore, the annual capacity of the fab (as well as each product line) will be 8,736 hours. In the semiconductor industry, it is customary to allow 25% of the full annual capacity for machine set-up, maintenance and other downtimes. Therefore, the practical utilization of each machine is 75% of full capacity. If needed, machines can be operated close to 100% capacity, but that would increase machine wear and tear and thus result in maintenance cost (around $200K max of additional cost). Exhibit 4 summarizes the initial investment, output per hour and the set-up time (time required to get the machine to operating condition) for each production line.

Anna took a careful look at the production line information.

EXHIBIT 4 - Production Lines

Production Line	Costs	Units Per Hour	Estimated Useful Life	Annual Capacity (in hours)	Setup Time (in months)	Ideal Utilization Rate
1	$6,000,000	122	8 years	8,736	0	75%
2	$7,500,000	160	8 years	8,736	0	75%
3	$10,000,000	224	8 years	8,736	0	75%
4	$20,000,000	456	8 years	8,736	0	75%

Anna: "Oh man!!! These are expensive machines; Do these have a good resale value?"

Jose: "Well there is a second-hand market for sure. However, I can't say that the resale value is good. If you think about it, semiconductor technology changes fast; so better machines come to market almost every year."

Bob: "So, let's say we want to sell a machine after using it for one year. How much can we recover?"

Jose: "If you sell a product line one year after purchasing, you will generate a loss from the sale of that production line. The loss on sale amount fluctuates from 5%-10% of the machine's book value, which is the production line costs minus the total accumulated depreciation at the point of sale. The longer you have/use the machine , the higher the loss on sale amount."

Anna: "I have another question. Since there is a large unmet demand, should we plan to do production scheduling to produce as much as we can?"

Jose: "We have to be careful here. I heard that typical inventory carrying costs for image sensors are about 12%."

Anna: "What does that mean?"

William: "Oh I know the answer to that one. Say the value of unsold inventory at the year end is $100. It will cost you $12 to hold that inventory, due to storage, insurance, finance costs etc."

Anna: "Wow!!! That means we have to be very careful in making our product line decisions and our production volume decisions."

Teresa: "Yes and yes!!! but really, we have to be very careful with all of our decisions. So each one of us should have an understanding related to all our business decisions."

Bob: "I have a question on the unsold inventory. Let's say at the end of year 1, we had some unsold inventory, Does that mean that we hope that we can sell those in year 2, or would we have to reduce the price?"

Jose: "Well, it depends on why the products did not sell right? If it is due to a price issue, then we can adjust the price and hope for the best. But if it was a quality issue, for example, if our product did not meet the minimum quality requirements of any customers, then even if we modify the price, no one will buy it right?"

Teresa: "Or it could be that our competitors had slightly better products and/or at a lower price. Anyways, let's say that our products did not sell because our quality did not meet the customer requirements, then is it possible to modify those?"

Jose: "Yep, it is possible and you'll incur incremental R&D costs to upgrade your product."

William: "Let's hope that our products are of super quality and we price them right and we don't have to worry about unsold inventories and carrying costs and what now. Let's keep moving !!! What's next?"

Anna: "Jose and Bob, you both probably understand manufacturing processes way more than William and I do. Can you guys compile some basic information related to image sensor production for us?"

Jose and Bob compiled the following information related to product costs. Product cost is based on three manufacturing resources: direct materials, direct labor, and manufacturing overhead. Product cost per unit is needed to calculate the gross profit and gross margin of each product.

- **Direct Materials**: Materials used to produce the image sensors (e.g. silicon wafers). This cost is roughly 60-85% of total product cost. Direct material cost depends on the product design (type and quantity of materials required) and the supplier pricing. Direct materials cost variation based on the design is due to the differences in product features. Based on information from competitor analysis, materials cost per sensor based on different product feature ranks are provided in Exhibit 3.
- **Direct Labor Costs**: These are production employee wages. These employees are paid at an hourly rate of $20 per hour. Direct labor hours are driven by production run hours (i.e. how long do the machines operate per period). It takes at least two employees to manage one production line and no employees can work more than two daily shifts (i.e. 16 hrs per day). 1 daily shift = 8hrs. Employees receive overtime pay at a rate of time and a half e for any hours they work over 40 hours per week. Using efficient machines (machines that produce more units per hour) reduces the need for labor hours; thereby reduces the labor cost.
- **Manufacturing Overhead Costs**: All manufacturing costs except for direct materials and direct labor costs are categorized as manufacturing overhead cost. A large portion of overhead cost is machine depreciation (i.e. depreciation of production lines). Manufacturing overhead cost is the second largest component of the product cost. We use the unit of production method to depreciate equipment. Manufacturing overhead costs are allocated to the individual products.

Anna and William, both business majors, read the descriptions and looked at each other and then looked at Bob.

Bob: "Why, is anything wrong?"

Anna: "Um… no!!! But will we have to calculate the direct materials cost, direct labor cost, and overhead cost, and then calculate the unit cost for each product?"

William: "Maybe we can hire an accountant to do that."

Bob: "Jose has talked to a couple of his friends about that. We will have a program which can calculate the unit product cost for us when we input the product features, volumes, and production line information. So, we don't have to calculate those and we don't need an accountant for that." Anna and William high-fived.

This is the end of information relating to the industry and market opportunity. Information about financing options will be visible after you login to the Market Games simulation, which we will show you how to do in class on Wednesday (10/25).