Will Intel's entry into the consumer discrete GPU market be effective in generating long-term profit?

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SL Business Management Internal Assessment

To Intel Corporation

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Acknowledgements

Thanks to the classmates that looked over my IA, to my mom for motivating me, and to my business teacher for pushing me to finish the report before the deadline.

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Introduction

Since 1968, the Intel Corporation has been known as one of the world's largest semiconductor chip manufacturing firms. Their success is largely derived from their CPU development; in fact, Intel is currently the biggest of the three companies licensed to manufacture x86 CPUs by market share ("Distribution of Intel CPUs"), the instruction set of which is the most widely supported among home computers ("AMD Market Share Record"). However, Intel also expanded its operations into the consumer discrete computer graphics market in Q1 2022 with their ARC series of GPUs ("Intel First-Quarter Financial Results" 2). Entry into this market is made difficult by the massive upfront development costs, with only 2 other companies having captured any meaningful market share (Statista Research Department 2022). As such, Intel must determine if it is worthwhile to continue investment into this segment, and so this IA strives to answer the following research question: Will Intel's entry into the consumer discrete GPU market be effective in generating long-term profit?

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Methodology

In this report, SWOT, Break-even, and Porter's Five Forces analyses were conducted using contents of Unit 1 - Organizational Objectives, Unit 3 - Finance and Accounts, and Unit 4 – Marketing of the IB Business curriculum respectively. A SWOT analysis will establish the key characteristics of Intel and its position in the GPU market. Then, a Porter's Five Forces analysis will expand on the competitive environment of this market, and a break-even analysis will calculate the point at which Intel can turn a profit selling their GPUs.

To aid these analyses, a research paper by the Institute for Defense Analyses was used for its thorough explanation of the supply chain issues Intel faces in GPU development. In addition, Intel's Q3 2022 earnings report was used, as it details the disruptions that impacted their GPU sales.

Several changes were made to the IA approach, such as the omission of a Forbes article as a supporting document due to the author's limited understanding of the product. Furthermore, the research question was altered to be more focused.

Most of the data collected for the break-even analysis was speculative, so the conclusions may not entirely be accurate. Also, bias exists in most of the sources used – for instance, the financial report may be somewhat biased because it is written by Intel themselves. However, a balance of both were used to mitigate its effect.

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Analysis and Discussion

SWOT Analysis

A SWOT analysis provides insight into the internal and external factors that may affect the number of discrete GPUs Intel will sell, and so it will help determine if the endeavor will be profitable long-term.

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	Strengths	Weaknesses
Internal	• Intel currently operates their own semiconductor manufacturing foundries (Odell et al. 2.1), and so they may be able to produce GPUs without outsourcing the silicon production process. • Intel has been producing graphics processors integrated into CPUs since 1998 (Peddie, Jon). • Intel has had some experience developing discrete GPUs with their Larrabee line of products (Cunningham, Andrew). As such, they already have skilled employees and experience in a related field, and so the R&D cost may be lower than it would be for other companies. • Intel has very good relations with large prebuilt OEMs like Dell and Acer (Moorhead, Patrick), and so	• Intel's semiconductor manufacturing facilities can currently only produce chips with their "Intel 7" process (Odell et al. 2.3), which is less powerful than the processes used by competing GPU manufacturers (AMD and Nvidia sell products with the more efficient TSMC 5nm and 4nm technologies respectively (Cutress, Ian)). This means that Intel must outsource the manufacturing of the GPU core (the most expensive component) to another company to improve their product's competitiveness (Odell et al. 2.4). • Intel does not have as high a semiconductor production capacity as their competitor TSMC, and so if they choose to use their own foundries to produce their GPUs, they would likely not be able to

	it is probable that these OEMs will sell Intel's ARC products to customers as a bundle rather than individually. This can help increase product adoption. • Intel is currently very financially successful in other parts of their business, with $15.3 billion USD in gross revenue generated in Q3 2022 alone. Their consistent cash inflow allows them to invest large sums of money into the development of products without the need of a short payback period, like in the case of the development of their ARC line of GPUs. ("Intel Third-Quarter Financial Results" 1)	manufacture enough units to satisfy demand (Odell et al. 2.4). • Intel's previous attempt to develop a GPU was not successful, as the product was not competitive with the rest of the GPU market and so the company cancelled all investment into the product as a graphics processor (Cunningham, Andrew). This may be indicative of the inefficiencies in their development process, and if this continued into the development of their ARC series of discrete GPUs, it is likely that their R&D costs would be higher than those of Nvidia or AMD. • Intel's current ARC GPUs are likely to be significantly more expensive to manufacture than their similarly priced competitor's products because of the inefficiencies in their GPU (see Appendix A), and so their profit margins must be lower than their competitors for the same tier of product.

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	Opportunities	Threats
External	• The PC market is relatively large, with an overall near-consistent growth overtime. For instance, 2021 saw nearly 340 million personal computers being shipped (Warren, Tom). In addition, the GPU market was predicted to grow at a rate of 32.82% compounded annually between the years of 2020 to 2028 (Statista Research Department 2022), which is indicative of the financial potential associated with entry into this market. • Lockdowns introduced by the COVID-19 pandemic have popularized working from home, and as such the market for personal home computers to fulfill this task has risen. Therefore, the market for consumer discrete GPUs to use within these computers has grown as well. (United States Census Bureau) • The current product offerings of the two major competitors in the consumer discrete GPU market (i.e., Nvidia and AMD) lean more towards the high-end/enthusiast segments ("Intel Third-Quarter 2022 Financial Results" 2), with comparatively worse-value products in the lower price segments (Walton, Steve). As such, it is possible that Intel could	• Though there are currently only 2 other competitors within the consumer discrete GPU market, they are both much more experienced and established as GPU manufacturers (Statista Research Department 2022). As such, they pose a great threat to Intel's success in the GPU market. • Although recent years have seen the GPU market grow substantially, the 3rd quarter of 2022 saw the lowest number of GPU shipments since 2009 (Statista Research Department 2022). The three major companies in the space have all attributed the sharp decrease in cryptocurrency mining, rolling shutdowns in China due to COVID-19 lockdowns, American sanctions/tariffs on foreign products, and increased material costs ("Intel Third-Quarter Financial Results" 5). As such, it may be less financially suitable for Intel to enter this market right now. • Game developer support for Intel's new ARC line of GPUs is sparse (Cunningham, Andrew), and so the usability of their products for the target market of desktop gamers is greatly diminished. This may damage their brand image, which may make it more difficult to generate longer-term revenue, even

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	more easily sell their lower-priced graphics cards to consumers in this segment without risking too much competition, as Nvidia and AMD are both using market skimming strategies to maximize profits.	if/when developer support improves in the far future.

Table 1: SWOT analysis of Intel and the consumer discrete GPU market

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Analysis

On the surface, Intel seems to be relatively well positioned to enter the market, with numerous strengths like their experience in GPU development and their immense capital providing them a competitive advantage. The market is also relatively opportune because of market conditions (like increasing demand from work-from-home). However, this is offset by weaknesses like the inefficiencies in their manufacturing process and their need for outsourcing. In addition, the other competitors' experience in the space and worsening economic conditions pose a great threat to Intel's success. Therefore, Intel's endeavor will likely not be profitable in the short term, and it will only be profitable in the long term if their weaknesses are dealt with and much more time and money is invested in the R&D of future products. However, the description of the competitive environment of the market is somewhat vague, and so the factors in the SWOT analysis will be expanded upon in a Porter's Five Forces analysis. It should also be noted that the significance of each weakness/threat and strength/opportunity is somewhat subjective, and so the conclusion drawn from such an analysis may not be concrete.

Porter's Five Forces Analysis

A Porter's Five Forces analysis will examine the competitive environment of the consumer discrete GPU market, and thereby the likelihood of Intel's graphics division generating long-term profit. It provides basis to the SWOT by expanding on the market conditions discussed.

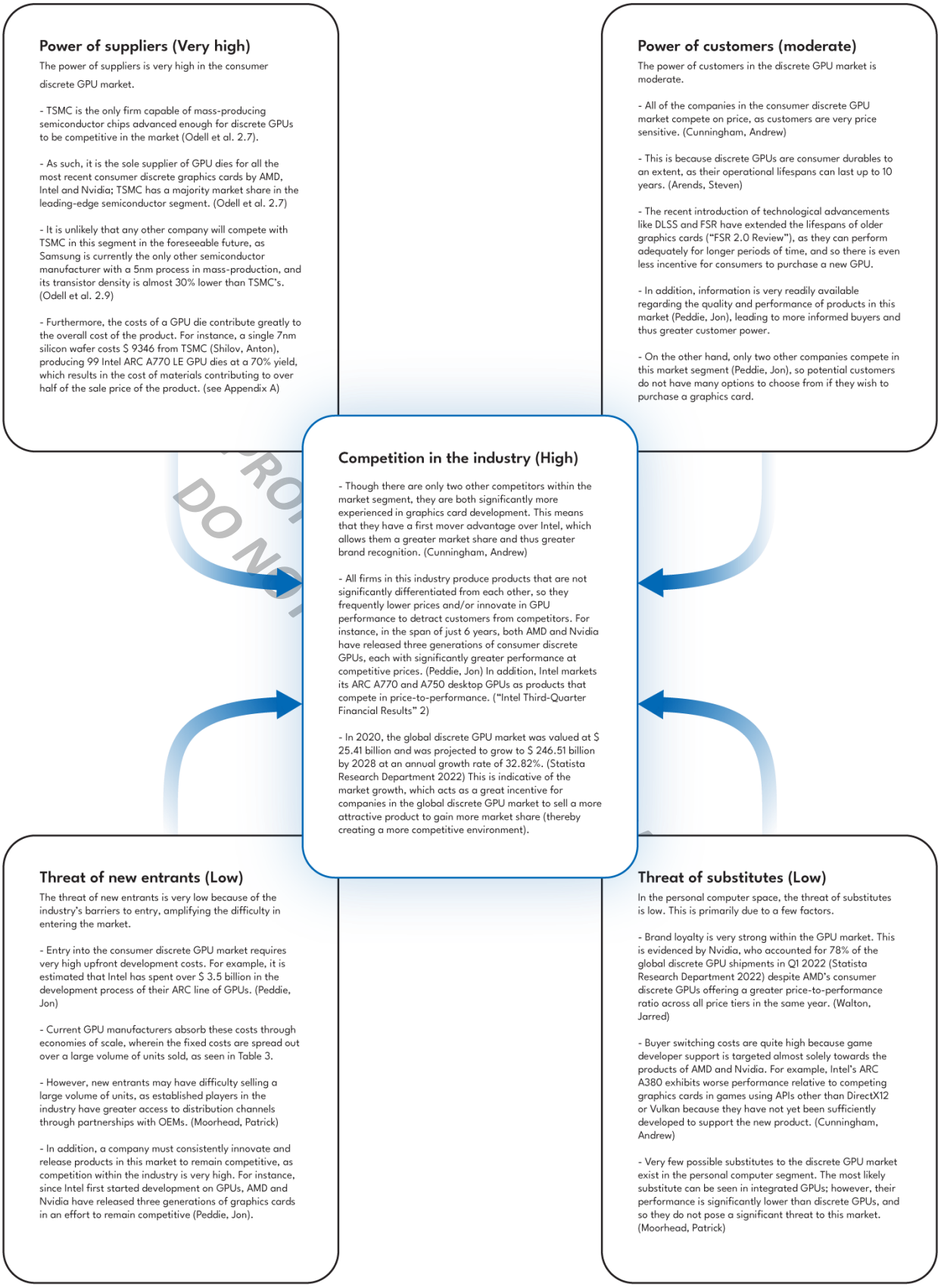

Figure 1: Porter's Five Forces Analysis of the consumer discrete GPU market

Of the five forces analyzed, two were classified as high level, one was moderate, and two were low. A low threat of substitutes is promising for Intel's entry into the market, indicating that there is a low possibility of an emerging technology like integrated graphics affecting Intel's GPU sales. In addition, the low threat of new entrants can be seen as a benefit to Intel, as it shows that there will likely not be any new competitors. However, the barriers to entry act as a detriment, as they have spent significant sums of money to overcome them. Furthermore, the moderate power of consumers signifies that Intel will be forced to innovate in price-to-performance to generate long-term profit.

The two high level forces pose a greater threat to Intel. The very high power of suppliers means that Intel's ability to generate long-term profit hinges on the wafer prices set by TSMC. Moreover, the high competition illustrates the immense difficulty in manufacturing a competitive product and gaining market share.

Therefore, the competitive environment that Intel is entering into is very strong, and so to generate long-term profit in their entry into the consumer discrete GPU market, they must overcome these major forces. Given the factors identified in the SWOT analysis, this may be achievable; for example, Intel's immense capital allows them to spend the money required to develop a product capable of generating profit in the market without greatly impacting the overall success of the business. To better understand the specific amount of investment needed, and thus the likelihood of Intel generating long-term profit in this segment, a break-even analysis will be conducted to compare the level of output required with the revenue generated so far.

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Break-Even Analysis

A Break-Even analysis is useful in determining the amount of revenue that must be generated from Intel's graphics division to overcome the costs associated with the development and manufacturing of their GPUs, and thus determines if they will turn a profit in the long-term.

Table 2: Intel ARC A770 LE Break-Even Analysis

Quantity sold (millions)	Fixed costs ($M) (Peddie, Jon)	Variable costs ($M) (see Appendix A)	Revenue ($M)	Profit / (Loss) ($M)
0	3,500.00	0	0	(3,500.00)
10	3,500.00	1,906.72	3,499.90	(1,906.82)
20	3,500.00	3,813.44	6,999.80	(313.64)
30	3,500.00	5,720.16	10,499.70	1,279.54
40	3,500.00	7,626.88	13,999.60	2,872.72
50	3,500.00	9,533.59	17,499.50	4,465.91
60	3,500.00	11,440.31	20,999.40	6,059.09
70	3,500.00	13,347.03	24,499.30	7,652.27
80	3,500.00	15,253.75	27,999.20	9,245.45
90	3,500.00	17,160.47	31,499.10	10,838.63
100	3,500.00	19,067.19	34,999.00	12,431.81

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Table 3: Intel ARC A770 LE Break-Even Calculations

Break-even level of output	$Break-even\ level\ of\ output = \frac{Fixed\ costs}{Contribution\ per\ unit}$ $Fixed\ costs = \$\ 3500000000$ (Peddie, Jon) $Contribution\ per\ unit = \$\ 159.32$ (see Appendix A)

	$Break-even\ level\ of\ output = \frac{\$\ 3500000000}{\$\ 159.32}$ $= 21968365$ ≈ 21.97 million units
Break-even revenue	$Break-even\ revenue = \frac{Fixed\ costs}{1-\frac{Direct\ cost}{Price}}$ $Fixed\ costs = \$\ 3500000000$ (Peddie, Jon) $Direct\ cost = \$\ 190.67$ (see Appendix A) $Price = \$\ 349.99$ (see Appendix A) $Break-even\ revenue = \frac{\$\ 3500000000}{1-\frac{\$\ 190.67}{\$\ 349.99}}$ $= \$7688708.26$ $\approx \$\ 7.69$ billion

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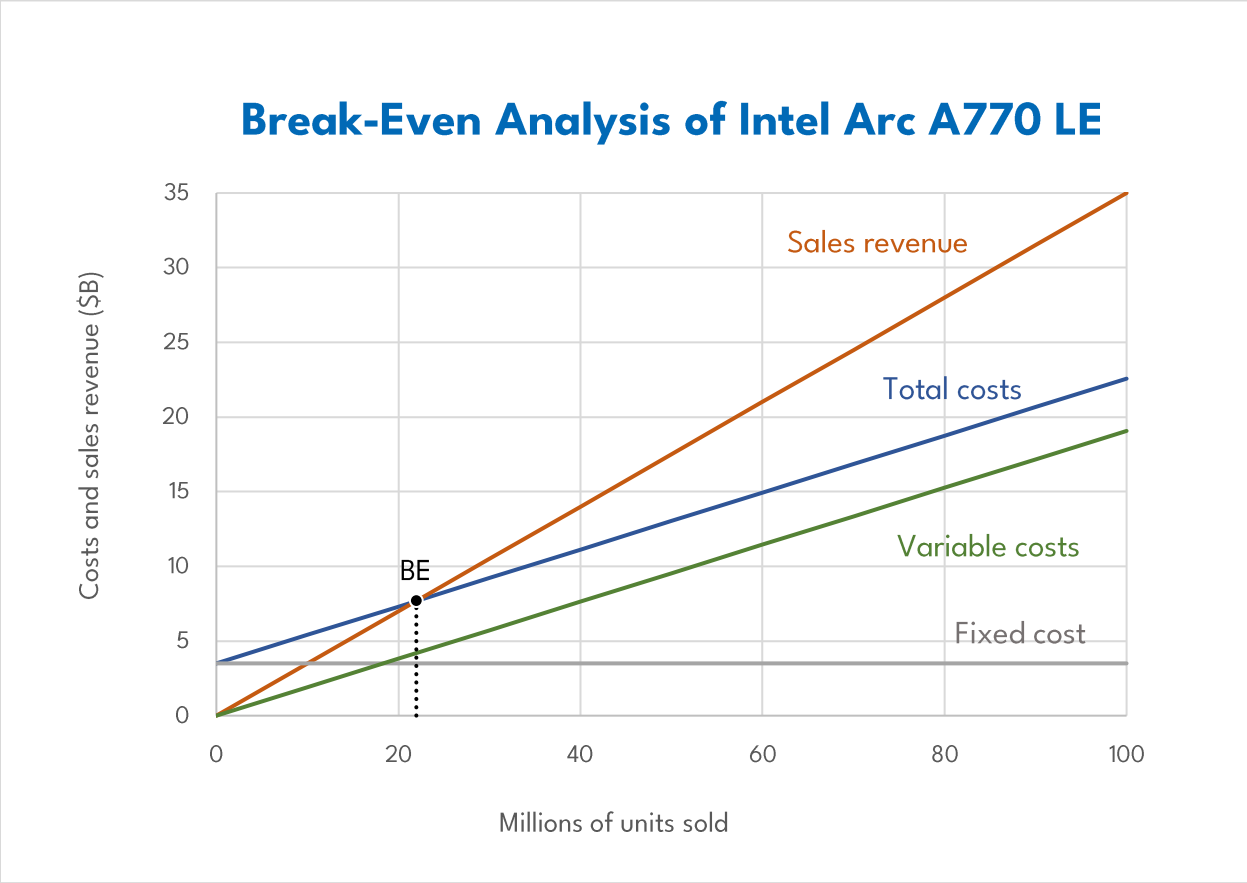
Fig. 2: Intel ARC A770 LE Break-Even Chart



For this break-even analysis, only one product was investigated for the sake of simplicity. The break-even analysis shows that to reach the break-even point, Intel must generate at least $7.69 billion USD in gross revenue from their graphics segment, which roughly equates to 21.97 million units sold. Though this is due in part to their immense fixed costs, it is more of a result of the manufacturing/development inefficiencies, which aligns with a major weakness revealed in the SWOT; Intel spends significantly more money manufacturing each unit than its competitors, so its profit margin is lower.

Given Intel's Q3 2022 earnings report, it is unlikely that the company will be able to recoup the costs of development in the short term, as they only generated $185 million USD from their entire graphics segment in that quarter. At their current rate, it would take roughly 41 months to reach the break-even point. This is not feasible because competition is fierce (as

revealed in the Porter's Five Forces analysis) and so continued innovation is required to maintain revenue – meaning increased investment is needed. However, it is likely that future R&D costs will decrease as time goes on because less money will be spent on already-developed features, such as XeSS (Cunningham, Andrew). Additionally, remedies to the manufacturing process could result in decreased production costs, and thus a lower break-even revenue. And given Intel's strong capital, they can likely afford the investments needed to reach this point, so it is conceivable that they may generate a profit in the long term in this market.

Conclusion

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Having entered the consumer discrete GPU market, the probability of generating long-term profit is of great importance to Intel. The SWOT analysis offered a preliminary outlook on their success in this market, showing that Intel faces great challenges due to internal weaknesses and external threats. The Five Forces analysis further developed Intel's likelihood of generating long-term revenue by revealing the highly competitive environment of the consumer discrete GPU market. Finally, a break-even analysis provided insight into the output required for them to generate a profit. Through these three tools, it was revealed that Intel must invest large sums of time and money to achieve long-term profit in this market. However, it was also revealed that the potential return on investment is very high, and so the prospect is very attractive. Intel is also well positioned to enter this market because of their experience in GPU development, and so it is likely that they will use their immense capital to fund the investments necessary to reach this point. Therefore, it is highly probable that Intel's entry into the consumer discrete GPU market will be effective in generating long-term profit.

It is important to note that certain key limitations exist within this IA. For instance, the fixed and variable costs in the break-even analysis are based on estimates by third parties (see Appendix A) because no publicly available data exists regarding Intel's costs and profit margins. As such, the calculated break-even point may not be entirely accurate; however, it provides a basic estimate of the quantity of units Intel must sell to reach this point, and so it's still useful in formulating a conclusion.

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Appendix A

The variable costs in Table 2, Table 3, and Fig. 2 are a summation of the following:

1. GPU die costs
2. GDDR6 memory module costs

In actuality, the manufacturing cost of the card should be higher because costs of other parts were not factored in, such as the cooler and PCB. This was because no publicly available information exists on the costs of those parts. Furthermore, other costs involved with the product such as shipping and customer service were not included because it is impossible to accurately estimate those values without information provided by Intel.

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1. The base of the calculation for the cost per GPU die is based on the GPU die size of an Intel ARC A770 LE, the diameter of a 7nm wafer, and the theoretical average yield.

   $Die\ size = 406\ \text{mm}^2$ ("Intel ARC A770 Specs")

   $Wafer\ diameter = 300\ \text{mm}$ (Shilov, Anton)

   $Average\ yield = 70\%$ (Zafar, Ramish)

   With these values, the number of GPU dies produced on average per wafer can be calculated. ("Die per Wafer Calculator")

$$Dies\ per\ wafer = (Wafer\ diameter)(\pi)\left(\frac{Wafer\ diameter}{4(Die\ size)} - \frac{1}{\sqrt{2(Die\ size)}}\right)$$

$$= (300)(\pi)\left(\frac{300}{4(406)} - \frac{1}{\sqrt{2(406)}}\right)$$

$$\approx 99$$

   Using the total cost per 7nm TSMC wafer, a manufacturing cost per die can be calculated.

   $Wafer\ cost = \$\ 9346$ (Shilov, Anton)

$$Cost\ per\ die = \frac{Wafer\ cost}{Dies\ per\ wafer}$$

$$= \frac{\$\ 9346}{99}$$

$$= \$\ 94.67$$

Therefore, each ARC A770 LE GPU die costs $94.67 to manufacture.

2. The cost of the GPU memory can be calculated by multiplying the number of memory modules by the price per module.

$Number\ of\ modules = 8$ ("Intel ARC A770 Review" 4)

$Price\ per\ module = \$\ 12$ (Sen, Seyan)

$$Memory\ cost = (Number\ of\ modules)(Price\ per\ module)$$

$$= (8)(\$\ 12)$$

$$= \$\ 96.00$$

After adding the memory cost and cost per die, a manufacturing cost per GPU of $ 190.67 is obtained. This is effectively the variable cost of the Intel ARC A770 LE GPU. The contribution per unit can be determined by subtracting the manufacturing cost from the MSRP of $ 349.99, which is $ 159.32.

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Appendix B

Supporting Document 1

Intel Third-Quarter 2022 Financial Results

Page 1

Exhibit 99.1

Intel Corporation
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Santa Clara, CA 95054-1549

News Release

Intel Reports Third-Quarter 2022 Financial Results

NEWS SUMMARY

- Third-quarter GAAP revenue of $15.3 billion, down 20% year over year (YoY), and non-GAAP revenue of $15.3 billion, down 15% YoY.
- Third-quarter results include GAAP restructuring charges of $664 million, reflecting initial cost reduction actions.
- The company is focused on driving $3 billion in cost reductions in 2023, growing to $8 billion to $10 billion in annualized cost reductions and efficiency gains by the end of 2025.
- Third-quarter GAAP earnings per share (EPS) was $0.25; non-GAAP EPS was $0.59.
- Listed Mobileye on the Nasdaq Stock Exchange this week.
- Revising full-year revenue guidance to $63 billion to $64 billion, reflecting continued macroeconomic headwinds.

SANTA CLARA, Calif., October 27, 2022 – Intel Corporation today reported third-quarter 2022 financial results.

"Despite the worsening economic conditions, we delivered solid results and made significant progress with our product and process execution during the quarter," said Pat Gelsinger, Intel CEO. "To position ourselves for this business cycle, we are aggressively addressing costs and driving efficiencies across the business to accelerate our IDM 2.0 flywheel for the digital future."

"As we usher in the next phase of IDM 2.0, we are focused on embracing an internal foundry model to allow our manufacturing group and business units to be more agile, make better decisions and establish a leadership cost structure," said David Zinsner, Intel CFO. "We remain committed to the strategy and long-term financial model communicated at our Investor Meeting."

Q3 2022 Financial Highlights

	GAAP			Non-GAAP		
	Q3 2022	Q3 2021	vs. Q3 2021	Q3 2022	Q3 2021	vs. Q3 2021
Revenue ($B)	$15.3	$19.2	down 20%	$15.3^	$18.1	down 15%
Gross Margin	42.6%	56.0%	down 13.4 ppts	45.9%	58.3%	down 12.4 ppts
R&D and MG&A ($B)	$6.0	$5.5	up 10%	$5.4	$4.8	up 12%
Operating Margin	(1.1)%	27.2%	down 28.4 ppts	10.8%	31.8%	down 21 ppts
Tax Rate	642.0%	0.5%	n/m[1]	(38.7)%	(4.2)%	n/m[1]
Net Income ($B)	$1.0	$6.8	down 85%	$2.4	$5.9	down 59%
Earnings Per Share	$0.25	$1.67	down 85%	$0.59	$1.45	down 59%

[1] *Not meaningful.*

In the third quarter, the company generated $1.0 billion in cash from operations and paid dividends of $1.5 billion.

Note: 2021 non-GAAP results excludes the NAND memory business. Intel completed the first closing of the divestiture on Dec. 29, 2021. Full reconciliations between GAAP and non-GAAP measures are provided below.

^ No adjustment on a non-GAAP basis.

Business Unit Summary

Intel previously announced several organizational changes to accelerate its execution and innovation by allowing it to capture growth in both large traditional markets and high-growth emerging markets. This includes the reorganization of Intel's business units to capture this growth and provide increased transparency, focus and accountability. As a result, the company modified its segment reporting in the first quarter of 2022 to align to the previously announced business reorganization. All prior-period segment data has been retrospectively adjusted to reflect the way the company internally manages and monitors operating segment performance starting in fiscal year 2022.

Key Business Unit Revenue and Trends	Q3 2022	vs. Q3 2021
Client Computing Group (CCG)	$8.1 billion	down 17%
Datacenter and AI Group (DCAI)	$4.2 billion	down 27%
Network and Edge Group (NEX)	$2.3 billion	up 14%
Accelerated Computing Systems and Graphics Group (AXG)	$185 million	up 8%
Mobileye	$450 million	up 38%
Intel Foundry Services (IFS)	$171 million	down 2%

Business Highlights

- Intel continues to make progress with its goal of achieving five nodes in four years. Intel 4 is progressing towards high-volume-manufacturing, and the company expects to tape out a production stepping of Meteor Lake in the fourth quarter, the final step in taking the 14th Gen Intel® Core® processors from the design phase to early production in silicon. Intel 3 continues to progress on schedule. On Intel 20A and Intel 18A, Intel's first internal test chips and those of a major potential foundry customer have taped out with products undergoing fabrication.
- In the third quarter, CCG launched the 13th Gen Intel® Core™ processors, which offer the world's fastest desktop processor and optimized gaming, content creation and productivity. CCG also introduced Intel® Unison™ to deliver best-in-industry multidevice user experiences.
- DCAI shipped its 4th Gen Intel® Xeon™ Scalable processor high-volume SKUs. In addition, Google Introduced its C3 machine series powered by Intel's 4th Gen Intel® Xeon™ Scalable processor and Google's custom Intel® Infrastructure Processing Unit E3200.
- NEX introduced its 12th Gen Intel® Core™ processors optimized for IoT applications, designed for use cases across retail, banking, hospitality, education, industrial manufacturing and healthcare.
- AXG launched the Intel® Data Center GPU Flex Series, giving customers a single GPU solution for a wide range of visual cloud workloads, and the Intel® Arc™ A770 and A750 desktop GPUs, bringing much-needed GPU pricing and performance balance to gamers around the world.
- This week Mobileye went public on the Nasdaq Stock Exchange, which Intel believes will unlock value for Intel's stockholders.
- IFS announced that NVIDIA has committed to joining the U.S. Department of Defense's (DOD) RAMP-C program, led by Intel, which enables both commercial foundry customers and the DOD to take advantage of Intel's at-scale investments in leading-edge technologies. In addition, since the second quarter, IFS has expanded engagements to seven of the 10 largest foundry customers, coupled with consistent pipeline growth to include 35 customer test chips.

During the quarter, Intel introduced the Semiconductor Co-Investment Program (SCIP), a new funding model for the capital-intensive semiconductor industry. As part of SCIP, Intel signed a definitive agreement with Brookfield Asset Management, one of the largest global alternative asset managers, under which the companies will jointly invest up to $30 billion in Intel's manufacturing expansion at its Ocotillo campus in Chandler, Arizona. The company also made progress toward creating a geographically balanced, secure and resilient semiconductor supply chain as it broke ground on two of the world's most advanced chipmaking facilities in Ohio. This site is intended to power a new generation of innovative products from Intel and serve the needs of foundry customers as part of the company's IDM 2.0 strategy.

plans. Variations in results can also be caused by the timing of Intel product introductions and related expenses, including marketing programs and Intel's ability to respond quickly to technological developments and to introduce new products or incorporate new features into existing products, as well as decisions to exit product lines or businesses, which can result in restructuring and asset impairment charges.

- Intel's results can be affected by adverse economic, social, political, regulatory, and physical/infrastructure conditions in countries where Intel, its customers or its suppliers operate, including recession or slowing growth, military conflict and other security risks, natural disasters, infrastructure disruptions, health concerns (including the COVID-19 pandemic), fluctuations in currency exchange rates, inflation, interest rate risks, sanctions and tariffs, political disputes, changes in government grants and incentives, and continuing uncertainty regarding social, political, immigration, and tax and trade policies in the U.S. and abroad. Results can also be affected by the formal or informal imposition by countries of new or revised export and/or import and doing-business regulations, including changes or uncertainty related to the U.S. government entity list and changes in the ability to obtain export licenses, which can be changed without prior notice. For example, in response to Russia's war with Ukraine, numerous countries and organizations have imposed financial and other sanctions and export controls against Russia and Belarus, while businesses, including the Company, have limited or suspended Russian operations. Russia has likewise imposed currency restrictions and regulations and may further take retaliatory trade or other actions, including the nationalization of foreign businesses.
- The COVID-19 pandemic has previously adversely affected significant portions of Intel's business and could have a material adverse effect on Intel's financial condition and results of operations. The pandemic has resulted in authorities imposing numerous measures to try to contain the virus, including manufacturing, transportation, and operational restrictions or disruptions, such as the Shanghai port shutdowns. These measures have impacted and may further impact our workforce and operations, the operations of our customers, and those of our respective vendors, suppliers, and partners. Restrictions on our manufacturing or support operations or workforce, or similar limitations for our vendors and suppliers, can impact our ability to meet customer demand and could have a material adverse effect on us. Restrictions or disruptions of transportation, or disruptions in our customers' operations and supply chains, may adversely affect our results of operations. The pandemic has caused us to modify our business practices. There is no certainty that such measures will be sufficient to mitigate the risks posed by the virus, and illness and workforce disruptions could lead to unavailability of our key personnel and harm our ability to perform critical functions. The pandemic has significantly increased economic and demand uncertainty. Demand for our products has been and could again be materially harmed in the future. The pandemic could lead to increased disruption and volatility in capital markets and credit markets, which could adversely affect our liquidity and capital resources. The degree to which COVID-19 impacts our results will depend on future developments, which are highly uncertain. The impact of the pandemic can also exacerbate other risks discussed in this section.
- Intel operates in highly competitive industries and its operations have high costs that are either fixed or difficult to reduce in the short term. In addition, we have entered new areas and introduced adjacent products, such as our intention to become a major provider of foundry services, and we face new sources of competition and uncertain market demand or acceptance of our offerings with respect to these new areas and products, and they do not always grow as projected.
- Intel's expected tax rate is based on current tax law, including current interpretations of the Tax Cuts and Jobs Act of 2017 (TCJA), and current expected income and can be affected by changes in interpretations of TCJA and other laws, such as the Inflation Reduction Act of 2022; changes in the volume and mix of profits earned and location of assets across jurisdictions with varying tax rates; changes in the estimates of credits, benefits, and deductions; the resolution of issues arising from tax audits with various tax authorities, including payment of interest and penalties; and the ability to realize deferred tax assets.
- Intel's results can be affected by gains or losses from equity securities and interest and other, which can vary depending on gains or losses on the change in fair value, sale, exchange, or impairments of equity and debt investments, interest rates, cash balances, and changes in fair value of derivative instruments.

Supporting Document 2

Supply Chain Risk in Leading-Edge Integrated Circuits

2.1

2. Key Actors in Leading-edge IC Markets

DoD defines leading-edge chips as those at <7nm and below.[34] Fundamentally, an IC is an assembly of microelectronic devices in a thin substrate of semiconductor material and interconnected by multiple layers of metal wiring. Components on an IC can include active devices (e.g., transistors and diodes) and passive devices (e.g., capacitors and resistors). Over time, these devices have shrunk significantly in size due to continual advances in the underlying fabrication technology. As transistors get smaller, the processes and equipment used to make them are substantially different from those used for previous generations, requiring capital, expertise, and commercial feasibility. This led to the significant reduction in the number of companies able to participate in leading edge sectors, with only one U.S.-based company pursuing the market -- Intel.

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A. The Last U.S. Leading-edge IC Manufacturer

Intel is the remaining U.S.-based integrated device manufacturer (IDM) company that designs and manufactures its own chips, after Advanced Micro Devices (AMD) and IBM sold their fabrication facilities to GlobalFoundries in 2009 and 2014, respectively. Intel's decision to focus on processors for servers instead of mobile technology throughout the 2000s prohibited the company from capitalizing on the massive growth trend in mobile, reducing their overall global competitiveness.[35] Intel's 10-K filings from the past few years have shown how the cost of manufacturing forced the company to restructure and cut costs in business lines that were not seeing growth. For example, Intel's Data Center Group's revenue grew 46% between 2015 and 2019, and its semiconductor production business (Programmable Solutions Group PSG, the former Altera FPGA business) only grew 15% over the same time, with a 6.4% annual decline in 2019.[36] In comparison, TSMC grew 27%

[34] https://nstxl.org/wp-content/uploads/2020/12/219G019-RAMP-C-RFS_FINAL-1-28-21.pdf.

[35] https://www.extremetech.com/computing/227816-how-intel-lost-the-mobile-market-part-2-the-rise-and-neglect-of-atom.

[36] "Form 10-K," Intel Corporation, January 24, 2020. https://www.intc.com/filings-reports/all-sec-filings/content/0000050863-20-000011/0000050863-20-000011.pdf.

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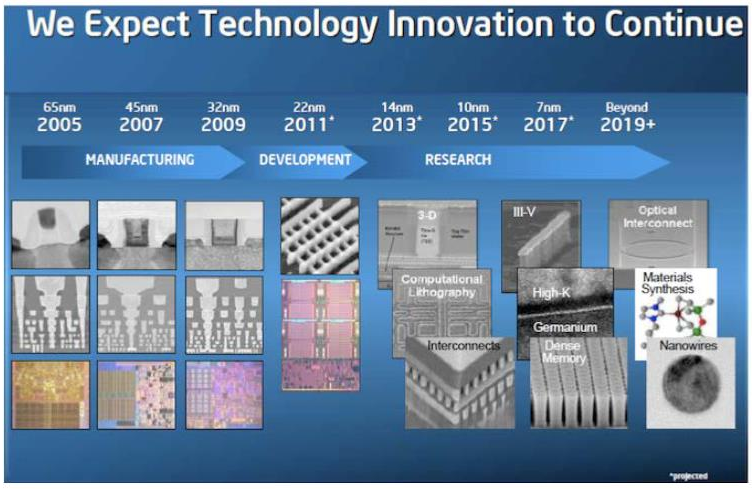

Note: Intel, 2010.

Figure 2-1. Planned Investor Roadmap

According to the roadmap, Intel planned to begin manufacturing of 10nm chips in 2015 and 7nm chips in 2017. The roadmap was initially on track with announcements in a 2013 10-Q[42] about the start of development for the 10nm chips; however, Intel has been plagued with delays in its 10nm manufacturing process. These issues, primarily with the level of yield,[43] continually pushed back the release date for Intel 10nm chips. As a result of these delays, development of the 7nm chips did not start until 2017.[44] However, Intel finally released its 10nm chips to market in 2019[45] and announced that the 7nm chips would be released in 2021[46]. Unfortunately, the 7nm manufacturing process has struggled with issues similar to those that plagued the 10nm process, and a flaw identified in the process has pushed manufacturing back until 2022 or 2023.[47] Figure 2-2 shows the significance of

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[42] https://www.intc.com/filings-reports/all-sec-filings/content/0000050863-13-000104/0000050863-13-000104.pdf.

[43] https://www.anandtech.com/show/12693/intel-delays-mass-production-of-10-nm-cpus-to-2019.

[44] https://www.intc.com/filings-reports/all-sec-filings/content/0000050863-17-000048/a2017q3-10qdocument.htm.

[45] https://www.pcgamer.com/intel-finally-launches-its-10th-gen-10nm-ice-lake-processors/#:~:text=Three%20years%20later%20than%20originally,changes%20to%20Intel's%20CPU%20architecture.

[46] https://d1io3yog0oux5.cloudfront.net/_d7114a2480a562d32f576af500351dd0/intel/db/861/7789/pdf/2019-Intel-Investor-Meeting-Davis.pdf.

[47] https://www.tomshardware.com/news/intel-announces-delay-to-7nm-processors-now-one-year-behind-expectations.

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this delay, as it will push Intel two entire nodes behind its nearest competitors (TSMC and Samsung). However, factors other than transistor performance and node sizes must be considered when comparing Intel, Samsung, and TSMC.

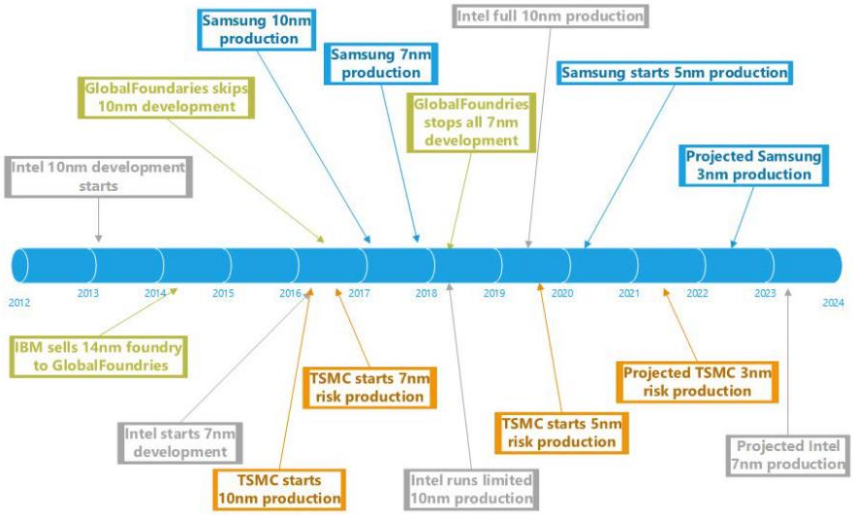

Figure 2-2. Leading-edge IC Timeline

Due to the continual delays putting Intel further and further behind its competitors, Intel made an agreement to use TSMC as a third-party foundry. Initial production will only be for Intel's lower-end chips starting in 2021 using TSMC's 5nm node but will eventually begin for the mid- to high-end chips later in 2022 using TSMC's 3nm node.[48] Intel also reported that its new 7nm discrete GPU will be built by TSMC.[49] This may impact Argonne's Aurora supercomputer, which was to use Intel's 7nm GPU.[50] Although both companies believe this to be more of a one-time deal,[51] with Intel stating that it still plans

[48] https://www.patentlyapple.com/patently-apple/2021/01/intel-to-outsource-5nm-core-i3-processor-with-tsmc-in-h2-2021-and-higher-end-3nm-core-processor-by-h2-2022.html#:~:text=its%20Technological%20Lead-,Intel%20to%20Outsource%205nm%20Core%20i3%20Processor%20with%20TSMC%20in,Intel%20beginning%20on%20February%2015.

[49] https://www.datacenterdynamics.com/en/news/intel-reportedly-plans-switch-tsmc-make-7nm-gpus/.

[50] https://www.tomshardware.com/news/us-governments-aurora-supercomputer-delayed-due-to-intels-7nm-setback.

[51] https://www.pcgamer.com/intel-tsmc-not-long-term/.

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C. Specific Research on TSMC

With the exception of Samsung, there is no company, globally, with the same scaling capability as TSMC within the manufacturing precision growth sector. GlobalFoundries ended efforts to attain 10nm and 7nm levels of precision, further narrowing the competitive market. Part of TSMC's ability to out-compete Intel arises from its status as a contractor for chip production. This enables the company to receive revenue from a variety of contracts and increases its return on investment in new manufacturing equipment while producing commodity, low-precision chips. TSMC benefits from never being a designer of chips—only a manufacturer of others' chips—and thus does not bear the costs or take the risks required to develop chips at an increasingly higher level of precision.

TSMC's competitive edge has increased over the last two years, acquiring major customers that had been with Intel for decades. As seen in Figure 2-1, TSMC has been pursuing a very aggressive strategy in constantly pushing to achieve the next node for manufacturing. This has led TSMC to gain a competitive edge at the leading edge of ICs. Because TSMC exclusively contracts manufacturing, it has dominated the market for Big Tech firms that need leading-edge IC in their products. Apple, for example, which has historically used Intel-based chips in its Macs, developed an Advanced RISC Machines (ARM)-based architecture that TSMC will produce for all foreseeable future products.[63] Microsoft, a longtime partner of Intel, recently announced that it will also design its own chips for PCs and servers[64] using an ARM-based architecture built by TSMC. Cloud computing is also moving heavily toward TSMC; Amazon Web Services (AWS) runs almost exclusively on ARM-based chips made by TSMC.[65]

TSMC is currently building a $12B fab in Arizona where several other high-tech manufacturers reside (including Intel). Current projections indicate that the fab is likely targeting the 5nm node for full-scale production at about 20,000 wafers per month.[66] Reports indicate that TSMC may have opened this facility as a means to curry favor with the U.S. government, which has allegedly pressured TSMC to open up a facility in the U.S. to specifically support business with the U.S. military.[67] The U.S. has been taking a critical look at TSMC due to its close relationship to Huawei and its potential to be influenced by the Chinese government due its geographic proximity and economic practices imposed on any company doing business in China.[68] In response, recent U.S. export controls and

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[63] https://www.wired.com/story/apple-mac-intel-switch-guide/.

[64] https://www.cnbc.com/2020/12/18/intel-falls-on-report-microsoft-will-design-own-chips-for-pcs-servers.html.

[65] https://www.nytimes.com/2018/12/10/technology/amazon-server-chip-intel.html.

[66] https://www.forbes.com/sites/willyshih/2020/05/15/tsmcs-announcement-of-a-us-fab-is-big-news/?sh=776f6f742340.

[67] https://hothardware.com/news/tsmc-under-pressure-to-build-chips-in-us.

[68] Ibid.

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Table 2-1. Representative Performance of Process Nodes

Process Node	14nm		12nm	10nm			7nm			5nm	
Company	Intel	Samsung	Global Foundries	Intel	Samsung	TSMC	Samsung	TSMC	TSMC	Samsung	TSMC
Transistor Density	37.5	30.59	36.71	100.76	51.82	52.51	95.3	96.5	113.88	126.5	173.1
Production Year	2014	2015	2017	2018	2017	2017	2018	2016	2018	2020	2019
Production Type	SADP	LELE	SAQP	SAQP	LELELE	SAQP	EUV	SAQP	EUV	EUV	EUV
Generation	1	1	1	1	1	1	1	1	2	1	1
Process Name	P1272	14LPP	12LP	P1274	10LPE	10FF	7LPE	7FF	7FFP	SLPE	N5

Intel's 10nm is currently more powerful than Samsung's 7nm and is marginally out performed by TSMC's second-generation 7nm node, with a density of 100.76 to 113.88, respectively. However, TSMC and Samsung have moved beyond the 7nm node and have started full-scale production of 5nm—TSMC's 5nm has significantly more transistors than Intel's 10nm. TSMC is also slated to start production of its 3nm node in 2021, which is marketed as having almost twice the transistor density of its 5nm line.[74] If Intel is able to replicate its performance targets for its 7nm node, then it is possible it will be competitive against the 5nm from TSMC and Samsung. However, there is still uncertainty on when Intel will be able to produce at the 7nm node and below. As seen in Table 2-1, the only other advanced foundry in the U.S. is GlobalFoundries, but it has decided not to invest below the 12nm node, and even there it is outperformed by the other manufacturers.

E. The Shift in Node Labeling

The use of node size has become more of a marketing label than any real measurement of performance. As discussed, Intel's 10nm node is physically smaller with comparative density to TSMC's 7nm node.[75] For older chip nodes (i.e., those greater than 20nm), the nanometer measure was a "real physical measurement inside the chip," but this

[74] https://www.anandtech.com/show/16024/tsmc-details-3nm-process-technology-details-full-node-scaling-for-2h22.

[75] https://www.oled-a.org/intel-lost-the-marketing-war-but-not-the-chip-density-competition_112920.html#.

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Supporting Document 3

Rumors, Delays, and Early Testing Suggest Intel's Arc Gpus Are on Shaky Ground.

Almost a year ago, Intel made a big announcement about its push into the dedicated graphics business. Intel Arc would be the brand name for a new batch of gaming GPUs, pushing far beyond the company's previous efforts and competing directly with Nvidia's GeForce and AMD's Radeon GPUs.

Arc is the culmination of years of work, going back to at least 2017, when Intel poached AMD GPU architect Raja Koduri to run its own graphics division. And while Intel would be trying to break into an established and fiercely competitive market, it would benefit from the experience and gigantic install base that the company had cultivated with its integrated GPUs.

Intel sought to prove its commitment to Arc by showing off a years-long road map, with four separate named GPU architectures already in the pipeline. Sure, the GPUs wouldn't compete with top-tier GeForce and Radeon cards, but they would address the crucial mainstream GPU market, and high-end cards would follow once the brand was more established.

FURTHER READING
Intel provides more details on its Arc GPUs, which will be made by TSMC

All of that makes Arc a lot more serious than Larrabee, Intel's last effort to break into the dedicated graphics market. Larrabee was canceled late in its development because of delays and disappointing performance, and Arc GPUs are actual things that you can buy (if only in a limited way, for now). But the challenges of entering the GPU market haven't changed since the late 2000s. Breaking into a mature market is difficult, and experience with integrated GPUs isn't always applicable to dedicated GPUs with more complex hardware and their own pool of memory.

Regardless of the company's plans for future architectures, Arc's launch has been messy. And while the company is making some efforts to own those problems, a combination of performance issues, timing, and financial pressures could threaten Arc's future.

The first Arc GPUs were initially targeted for early 2022, and Intel managed to announce a pair of low-end 300-series laptop GPUs at the tail end of March. To date, the number of those laptops that is actually available for purchase is relatively small, and no one in the US has been able to buy anything else. A desktop version of the 1080p-focused Arc A380 has appeared in China, though, and a few publications have managed to import and test it.

We can only infer so much about the performance of higher-end Arc cards based on these two entry-level GPUs, but early reports have been mixed at best. On the positive side, the low-end Arc GPUs are an improvement over integrated graphics, and the A380 can trade blows with sub-$200 GPUs like AMD's Radeon RX 6400 and Nvidia's GeForce GTX 1650. Intel's support for hardware-accelerated encoding and decoding of the royalty-free AV1 video codec could also be a big deal for streamers, and Intel is ahead of Nvidia and AMD here. The bad news is that performance is maddeningly inconsistent, with wild swings between one game and the next, and some of the GPUs the A380 is running neck-and-neck with are years old.

The A380 has also exhibited quirks that are likely to be present across the Arc lineup. The GPU's performance takes a dive when used in a system without Resizable Base Address Memory (alternatively referred to as Resizable BAR, ReBAR, Smart Access Memory, or SAM by various GPU and motherboard makers). Resizable BAR, which allows the CPU to access the GPU's entire pool of VRAM instead of addressing it in 256MB chunks, can help at the margins with newer GeForce and Radeon GPUs. But Arc GPUs seem to *need* it to perform well in a way that isn't true for other cards. Almost all modern motherboards do support Resizable BAR, and some older boards can do it after a BIOS update, but older systems and OEM-built PCs with limited BIOSes may not be able to enable it.

Arc's performance is also worst when playing older games that don't support the DirectX12 or Vulkan APIs, pointing to one huge issue that Intel has openly acknowledged: The company is struggling with its GPU drivers.

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Whether the issues are being caused by hardware, software, or some combination of the two, Intel's leadership and shareholders may not have infinite patience for the graphics team's problems. And we've seen this play out before with Intel multiple times.

FURTHER READING
Intel tries to get its chip manufacturing back on track with "Intel 4," due in 2023

The company is under a lot of pressure to improve its execution after giving up a years-long manufacturing lead to the likes of TSMC and Samsung and losing PC and server market share to AMD's Ryzen chips. It would be one thing for the graphics division to lose $500 million in one quarter if the rest of the company was doing great, but that isn't the case right now. Issues like softening demand for PCs and stiff competition from AMD are leading to big bites being taken out of Intel's consumer PC and server business.

Regardless of whether sensational YouTuber claims of the Arc lineups' imminent cancellation are true (and we likely won't know for sure until and unless Intel itself makes an announcement), it's a lot of time and money to invest at a time when the most profitable divisions of the company are stumbling.

FURTHER READING
Intel slipped—and its future now depends on making everyone else's chips

That's doubly true for an extant, sometimes-volatile market segment with entrenched competitors. If Intel enters the dedicated GPU market with products that are already behind the competition in both performance and power consumption, it will be difficult to claw market share away from them without either undercutting them on price or catching up. Selling low-margin "budget options" isn't likely to make a ton of money, especially not compared to the potential upside from the company's nascent foundry business. And catching up with a moving target is *difficult*; just look at how Intel's efforts to break into smartphone SoCs and cellular modems went last decade (the short version is that the company struggled to break through and eventually cut its losses).

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Supporting Document 4

Will Axg Survive Gelsinger's Axe?

Intel's financial report revealed two hard-to-ignore situations. In a quarter where the company reported a loss combined with dropping margins and sales, Pat Gelsinger also jettisoned several non-essential business units that contributed to the drain.

Of the groups Gelsinger got rid of was Optane (started in 2017, never made a profit), sold McAfee (bought in 2010, never made a profit), and shut down the drone group (started in 2015, never made a profit). Last year, Intel sold off its NAND business to Hynix, giving up its only Chinese fab, and sold off its money-losing sports group; and this year, the company shut down its Russian operations. Since Gelsinger's return, Intel has dumped six businesses, saving $1.5 billion in operating costs and loses.

Gelsinger is not afraid to make tough decisions and kill pet projects if they don't produce—even projects he may personally like.

So, is the company's dGPU group next? Started in 2016 the dGPU group snatched showboater Raja Koduri away from AMD with great fanfare in 2017— it looked like Intel was all in. And they were. The hiring continued unabated up till 2021 when they got their latest prize, Tom Petersen from Nvidia. Almost anyone who could spell GPU could get a job at Intel.

Since Q1'21 when Intel started reporting on its dGPU group, known as AXG or accelerated graphics, the company has lost a staggering $2.1 billion and has very little to show for it.

In fact, the company has actually invested more than that. We estimate the number is closer to $3.5 billion (or more, depending on how Intel chooses to account for those investments, and the setup costs at TSMC).

Should Intel dump its AXG group? Probably. The company started the project six years ago. Since then, AMD and Nvidia have brought out three generations of new and stunningly powerful dGPUs, and more are in the pipeline. Four new companies have started up in China, and two new ones announced in the US. Intel is now facing a much stronger AMD and Nvidia, plus six start-ups—the rules of engagement have dramatically changed while Intel sunk money into projects it can't seem to get off the ground.

Not many CEOs would put up with that, especially while repairing their company from previous misguided investments. Gelsinger was brought in to clean things up and get back to the company's core strengths. The dGPU program is noble in its concept, intriguing in its alleged design, and an adventure too great for even Intel, especially in these days of recovery.

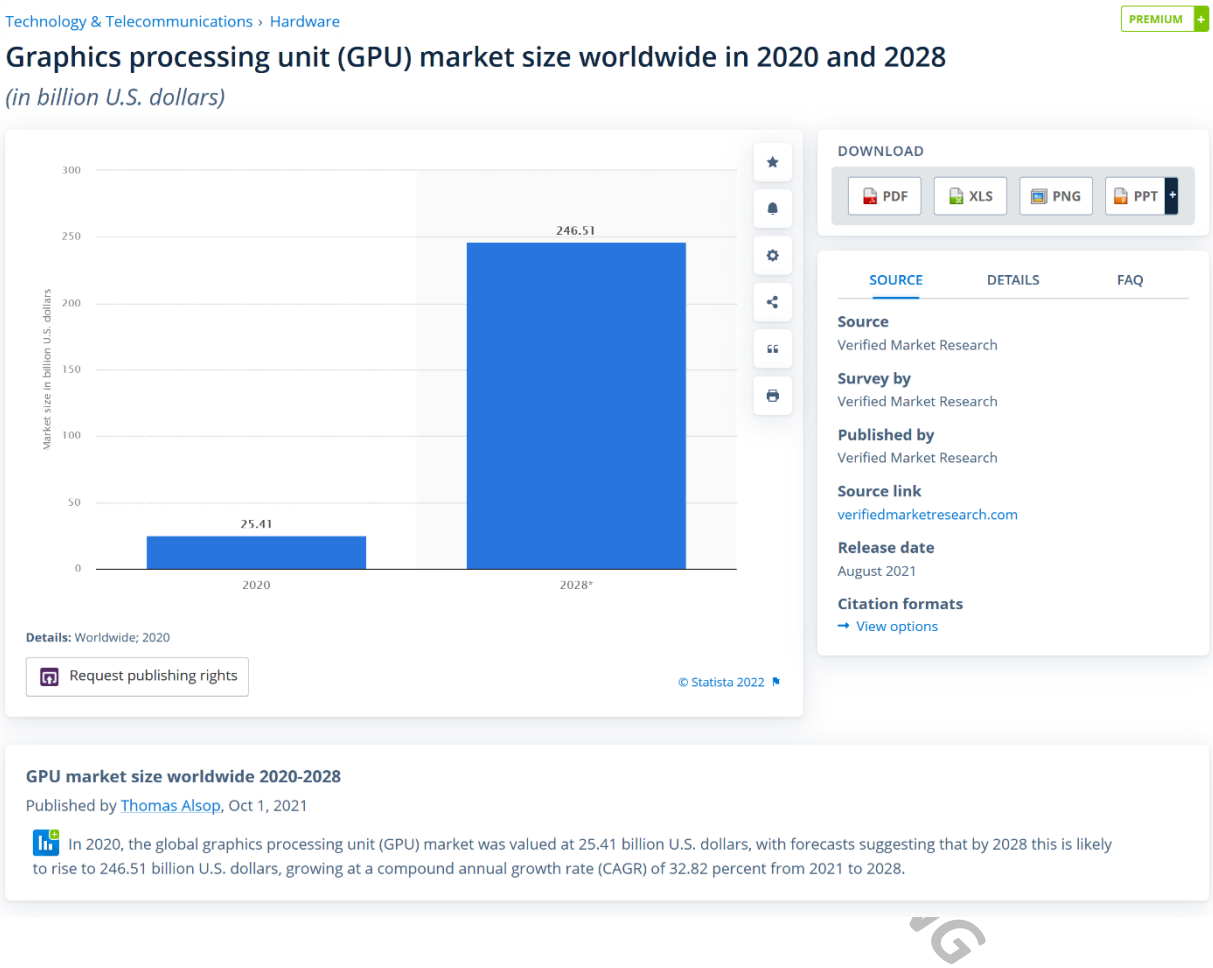
The best thing Intel could do at this juncture is to find a partner and sell off the group. It could even be dressed up as a strategic move, just as they did going to TSMC to build the dGPU in the first place. The company can't continue to carry an enormous payroll, pay a competitive fab for wafers, and then ask governments to subsidize its investments in new fabs that can't even build the parts they are presumably designing. Not only is that a bewildering investment strategy, but it's also an embarrassment.

At this point, being one of the blind men feeling the Intel elephant, it's a 50–50 guess whether Intel will wind things down and get out. If they don't, the company is facing years of losses as it tries to punch its way into an unfriendly and unforgiving market.

Perhaps the clouds will lift by the end of this quarter.

Supporting Document 5

Graphics processing units (GPUs) - statistics & facts



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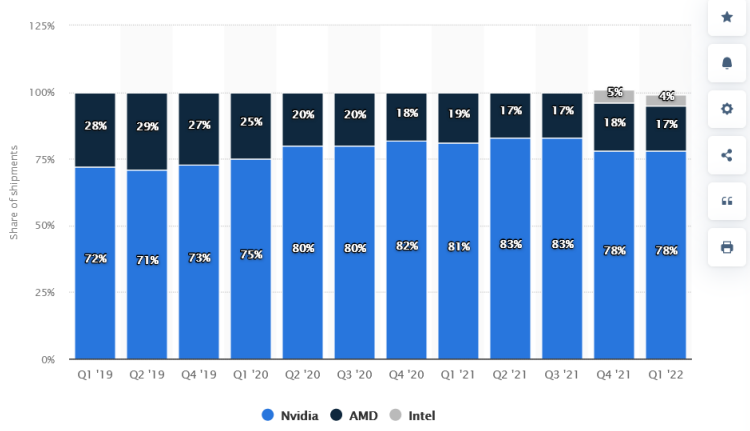
PC discrete graphics processing unit (dGPU) shipment share worldwide from 1st quarter 2019 to 1st quarter 2022, by vendor



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