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Teradyne

Positive on Fundamentals, but Valuation Remains Rich in Light of Cyclicality; Initiate at Neutral

We are initiating coverage of Teradyne (TER) with a Neutral rating on the balance of strong growth fundamentals in leverage to growth in WFE spend and architecture transitions combined with a leading market position in semiconductor testing and "sticky" customer relationships, against the cyclicality introduced by timing of adoption of new architectures by a concentrated customer footprint and an already rich valuation multiple. We are confident relative to the high-single-digit revenue and earnings growth forecasts but less confident relative to a secular valuation multiple in excess of 20x+ for a cyclical business, and our Dec-22 price target of $120 is based on an 18x multiple.

- **Leadership in Semiconductor Test equipment – market set for robust high-single-digit growth.** Teradyne is one of the main two players in the Semiconductor Test (SoC & Memory) market, with broad end-market exposure, including smartphones, compute, automotive, and industrials. Teradyne's key differentiation is its "stickiness" with large customers, including Apple, Samsung, Mediatek, Broadcom, and Qualcomm. With leverage to WFE (Wafer Fab Equipment) spend long term and node transitions and architecture changes near-term, TER is well positioned for a +7% revenue CAGR through FY24.

- **Node transitions drive revenues to be cyclical; upside in 2023 from 3 nm transition.** Following a year of weak demand in Semiconductor Test from a delay in new technology adoption, Teradyne is on the cusp of revenue inflection starting in 2023 from TSMC's introduction of 3 nm (Apple is one of the primary customers), followed by an industry-wide transition to DDR5 and LPDDR5, which we expect will increase complexity for Memory test. On the flipside of an enviable position with "stickiness" of customers and, in some cases, sole supplier position is revenue concentration with few customers driving revenue to be tied to decisions on technology adoption.

- **Diversification into Industrial Automation to offset cyclical Test revenues.** Teradyne has emerged as the leading provider of collaborative robots ("cobots"), as well as the second largest player in autonomous mobile robots ("AMRs"), driving IA revenues to expand at a +44% CAGR (albeit off a low base) since its inception in 2015. With growth forecasts in IA of a +30% CAGR in FY21-FY24, scaling of IA will drive diversification for Teradyne.

- **Earnings growth largely in line with revenue as investments in IA are offset by buybacks.** We forecast robust revenue growth of about +7% to translate to an +8% EPS CAGR in FY21-FY24, largely on account of lower-than-expected operating leverage from slowing growth in IA in a tough macro as well as a continued higher pace of investments at a 10% CAGR, offset by accretion from allocation of capital towards buybacks in near-term preference over M&A.

- **Introducing Dec-22 price target of $120 on 18x multiple**, appropriate for the solid growth fundamentals accompanied by cyclicality of revenue and earnings.

Sources for: Style Exposure – J.P. Morgan Quantitative and Derivatives Strategy; all other tables are company data and J.P. Morgan estimates.

See page 39 for analyst certification and important disclosures, including non-US analyst disclosures.

Initiation

Neutral

TER, TER US

Price (01 Jul 22): $85.80

Price Target (Dec-22): $120.00

Telecom & Networking Equipment/IT Hardware

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Quarterly Forecasts (FYE Dec)

Adj. EPS ($)

	2021A	2022E	2023E
Q1	1.11	0.98A	1.47
Q2	1.91	1.13	1.77
Q3	1.59	1.25	1.79
Q4	1.37	1.40	1.61
FY	5.96	4.75	6.65

Style Exposure

Quant Factors	Current %Rank	Hist %Rank (1=Top)			
		6M	1Y	3Y	5Y
Value	48	53	54	59	28
Growth	44	42	59	65	77
Momentum	63	24	39	20	17
Quality	11	5	7	4	42
Low Vol	49	41	40	50	18
ESGQ	26	95	66	5	81

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05 July 2022

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Price Performance

	— TER Price ($)	— S&P500 (rebased)		
	YTD	1m	3m	12m
Abs	-48.4%	-19.5%	-26.3%	-33.7%
Rel	-28.7%	-12.8%	-10.4%	-22.2%

Company Data

Shares O/S (mn)	175
52-week range ($)	168.91-84.22
Market cap ($ mn)	15,056.78
Exchange rate	1.00
Free float(%)	99.6%
3M - Avg daily vol (mn)	1.79
3M - Avg daily val ($ mn)	185.0
Volatility (90 Day)	52
Index	S&P 500
BBG BUY|HOLD|SELL	12|6|0

Key Metrics (FYE Dec)

$ in millions	FY21A	FY22E	FY23E	FY24E
Financial Estimates				
Revenue	3,703	3,425	4,233	4,587
Adj. EBIT	1,231	980	1,322	1,448
Adj. EBITDA	1,357	1,096	1,469	1,606
Adj. net income	1,051	807	1,089	1,199
Adj. EPS	5.96	4.75	6.65	7.55
BBG EPS	5.89	4.83	6.42	7.30
Cashflow from operations	1,098	758	1,168	1,299
FCFF	966	594	977	1,092
Margins and Growth				
Revenue growth	18.6%	(7.5%)	23.6%	8.3%
EBIT margin	33.3%	28.6%	31.2%	31.6%
EBIT growth	30.0%	(20.4%)	34.9%	9.5%
EBITDA margin	36.6%	32.0%	34.7%	35.0%
EBITDA growth	26.4%	(19.2%)	34.0%	9.4%
Net margin	28.4%	23.6%	25.7%	26.1%
Adj. EPS growth	30.0%	(20.4%)	40.1%	13.6%
Ratios				
Adj. tax rate	14.5%	15.9%	16.4%	16.0%
Interest cover	-	-	-	-
Net debt/Equity	NM	NM	NM	NM
Net debt/EBITDA	NM	NM	NM	NM
ROE	44.0%	32.2%	40.8%	38.3%
Valuation				
FCFF yield	6.4%	4.1%	7.0%	8.0%
Dividend yield	0.5%	0.5%	0.5%	0.6%
EV/Revenue	4.3	4.7	3.8	3.5
EV/EBITDA	11.8	14.7	10.9	10.0
Adj. P/E	14.4	18.1	12.9	11.4

Summary Investment Thesis and Valuation

We rate Teradyne shares Neutral, led by favorable market competition dynamics as one of two main players in Semiconductor Test and high level of "stickiness" with major customers. Following a downcycle in 2022, Teradyne expects a revenue inflection starting in 2023 from TSMC's introduction of 3 nm (for which Apple is a primary customer), as well as from other technology transitions that drive greater complexity and need for testing. In addition, TER is diversifying into Industrial Automation, in which it has an early leading position, helping to offset cyclicality associated with the Test business. The above leads us to forecast a high-single-digit revenue and earnings growth CAGR through FY24, albeit with pronounced cyclicality. However, we are less confident about the long-term drivers justifying TER shares to trade at an average of 20x+ P/E, given the cyclicality in both revenue and earnings around technology transition timing, as well as a much lower trading multiple for closest competitor Advantest, trading at 14x 2022E (vs. TER at 20x).

We introduce our Dec-22 price target of $120 based on applying an 18x P/E multiple to our 2023E EPS of $6.65. We believe the target multiple, which is still modestly above the peer group average, is justified on the balance of a robust revenue and earnings outlook relative to peers, while embedding risk of downcycles.

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Table of Contents

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North America Equity Research
05 July 2022

J.P.Morgan

Investment Thesis

Teradyne (TER)

Neutral

Leadership in Semiconductor Test equipment – market set for robust growth in the high-single-digit range

Teradyne is one of the two main players in the Semiconductor Test (SoC & Memory) market, with Teradyne and Advantest comprising ~85-90% of the market, and has broad end-market exposure, including smartphones, compute, automotive, and industrials. Teradyne's key differentiation is its "stickiness" with major customers, including Apple, Samsung, Mediatek, Broadcom, and Qualcomm. With leverage to WFE (Wafer Fab Equipment) spend in the long term as well as leading node transitions and architecture changes in the near term, Teradyne is well positioned to deliver high-single-digit revenue growth over a multi-year period, largely in line with growth the company has delivered historically.

Node transitions drive revenues to be cyclical; upside seen in 2023 from 3 nm transition

Despite the long-term growth CAGR in the high-single-digit range, the growth from the company has hardly been linear, and it is expected to remain similarly non-linear going forward. Following a year of weak demand in Semiconductor test from a delay in new technology architecture adoption, we expect Teradyne to be on the cusp of a revenue inflection starting in 2023 from TSMC's introduction of 3 nm (Apple is one of the primary customers), followed by an industry-wide transition to DDR5 and LPDDR5 within Compute, which we expect will increase complexity for Memory test.

Sole supplier status with Apple is largely a boon, though could pose a risk

Teradyne has an enviable position in Semiconductor test with "stickiness" of customers and in some cases sole supplier position with large customers, although on the flipside Teradyne has revenue concentration with few customers, which drives revenue volatility tied to customer decisions on technology architecture adoption as well as test efficiency initiatives. For example, Teradyne's largest indirect customer, Apple, makes up ~20-25% of its overall business, and Teradyne is sole sourced as a Test provider to Apple (via TSMC). This greatly benefited Teradyne in 2020/2021, driven by a step-up in iPhone volumes and market share gains through the pandemic; however, Teradyne's medium-term growth outlook is dependent on Apple transitioning to the 3 nm node for its next line of devices, which is now expected to begin later this year.

System and Wireless Test businesses are other levers for the business

In addition to forecasting mid-single-digit growth for Teradyne revenues in Semiconductor test (SOC, and Memory) in FY21-FY24, we see additional growth leverage in System Test – although a smaller mix of revenue for the company relatively. System Test, which is comprised of Storage Test, Defense & Aerospace Test, and Production Board Test, is levered to secular exabyte-level growth in storage requirements, as well as an increasing focus on defense & aerospace spending in an uncertain geopolitical landscape. Meanwhile, Wireless Test (also known as LitePoint) is levered to 5G cellular standards, Wi-fi 6/6E/7, and other connectivity standards (e.g., GPS, Bluetooth), for which growth in complexity with each new standard release drives greater test requirements. In combination, we

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expect System and Wireless Test revenues to grow at a low- to mid-single-digits CAGR.

Diversification into Industrial Automation to offset cyclical Test revenues

After three acquisitions of automation companies, Teradyne has emerged as the leading provider of collaborative robots ("cobots") with roughly 45% market share, as well as the second largest player in autonomous mobile robots ("AMRs") with roughly 8% of market share. Industrial Automation revenue has grown at a +44% CAGR (albeit off a low base) since its inception in 2015, driven by a combination of: 1) very low market penetration, estimated <3%, of cobots/AMRs; 2) a secular shift to automation due to a skilled labor shortage and diminishing economics of offshore labor; and 3) short ROI of about a year or less for both cobots and AMRs. With growth forecasts in IA of a 30% CAGR in FY21-FY24, we expect the scaling of this segment to drive solid diversification for Teradyne revenues along with a modest boost to top-line growth. That said, IA is levered to manufacturing investments and likely to see moderating growth in the backdrop of a slowing macro in the near term.

Upcycle in technology includes +24% growth in 2023 and +8% growth in 2024 helped primarily by transition of customers to 3nm

After robust growth in 2020 and 2021 (+36% and +19%, respectively), we are modeling a decline of -8% in 2022 on account of the cyclicality associated with node transitions, as well as supply constraints. However, in 2023, we model a strong revenue ramp, mainly boosted by the transition to 3 nm at TSMC, and also helped by +30% growth in Industrial Automation. In 2024, we still model double-digit growth on account of the longer tail of customers transitioning to 3 nm as well as continued strength in IA. Put together, we forecast +7% Test revenue CAGR between FY21 and FY24, largely in line with the revenue growth track record for the company in the past.

Earnings growth largely in line with revenue, as investments in IA are offset by buybacks

We expect the robust revenue growth of about 7% to translate into an 8% EPS CAGR in FY21-FY24, largely on account of lower-than-expected operating leverage from slowing growth in IA in a tough macro as well as a continued higher pace of investments at a 10% CAGR, offset by accretion from allocation of capital towards buybacks in near-term preference over M&A.

Confidence in revenue and earnings forecasts is high, but we believe the valuation multiple is not justified by the cyclicality

We feel relatively confident about our revenue and earnings growth forecasts through FY24, despite the declines in FY22. However, we are less confident about the long-term drivers justifying TER shares to trade at a 20x+ P/E, given the cyclicality in both revenue and earnings around technology transition timing, as well as a much lower trading multiple for closest competitor Advantest, trading at 14x.

Introducing December 2022 price target of $120 on 18x multiple

We are initiating on shares of Teradyne with a Neutral rating using an 18x P/E multiple, which sits between the current trading multiple and Advantest's multiple, led by: 1) 14x multiple, similar to Advantest is inexpensive for the high-single-growth and technology leadership in semiconductor test equipment, and 2) 20x historical trading multiple is a secular multiple for a rich for a cyclical company,

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although cyclicality likely will moderate with rapid growth in IA. Our Dec-22 price target of $120 implies about +40% upside potential from current levels.

Risks to Rating and Price Target

Industry Upside Risks

- Adoption of leading edge nodes and technology architecture changes like chiplet designs as well as gate-all-around architectures could track faster than expected, requiring greater test times for smartphone, tablet, and compute applications.

- New cellular and Wi-fi standards are more complex than expected, leading to greater demand for Wireless Test capabilities.

- The use cases for collaborative robots and/or autonomous mobile robots increase, or industrial companies adopt automation tools more rapidly than expected.

Company-Specific Upside Risks

- Teradyne is able to gain market share from competitors, e.g., gaining a foothold in Compute, displacing Advantest, using architecture changes as an insertion opportunity.

- Adoption of DDR5/LPDDR5 is faster than expected, which requires greater test times given the increase in complexity, and drives growth in the Memory Test market.

- Adoption of chiplet architecture in compute customers is faster than expected, creating more test opportunities for unique individual chiplets as well as mechanisms between chiplets all in one package.

- Teradyne is able to scale the Industrial Automation segment faster than expected leading to faster diversification and moderation of the cyclicality of the business.

Industry Downside Risks

- The pace of node advancements (e.g., from 3 nm to 2 nm) slows materially as companies reach physical limitations in transistor count on smaller nodes and delay transition to chiplet architectures given the associated complexity. Slowing growth in complexity or slower transitions to newer architectures will diminish testing requirements and test time needed.

- Migration to industrial automation slows due to macro pullback or other secular shifts.

- Customers find testing efficiency, which moderates demand for test equipment.

Company-Specific Downside Risks

- Apple does not adopt 3 nm for its next product cycle in 2H22/2023 or adopts it for only a minority of the product portfolio.

- Teradyne cedes share to competitors due to slowing technological innovation or poor execution.

- Different industrial automation technology emerges as the preferred technology among customers.

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Company Description

Teradyne designs, develops, and manufactures automated systems used to test and validate equipment, as well as industrial automation products used to improve manufacturing efficiency for industrial customers. Operating segments include Semiconductor Test, Wireless Test, Industrial Automation, and System Test, the last of which encompasses Storage Test, Defense/Aerospace Test, and Production Board Test. The company ended FY21 (Dec-end) with $3.7 bn in revenue.

Teradyne was incorporated in 1960 in Massachusetts, where it is still headquartered today. The company completed its initial public offering (IPO) on the New York Stock Exchange in 1970 and transferred its listing to Nasdaq in 2018, and is quoted under the trading symbol: TER.

### Semiconductor Test accounts for majority of revenue

As shown in Figure 1, below, Teradyne derives about 70% of its revenue mix from Semiconductor Test, while the remaining 30% of revenue is split between System Test, Industrial Automation, and Wireless Test. Overall, that revenue mix has stayed consistent over the years since the company's acquisition of Universal Robots, an industrial automation company, in 2015, as illustrated in Figure 2.

Figure 1: TER Segment Revenue Mix (2021)
%
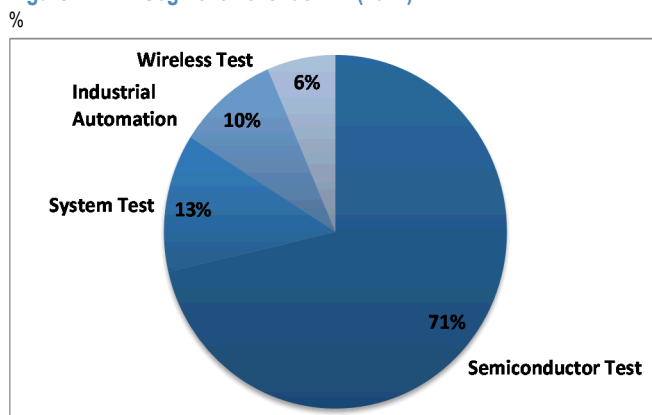
Source: Company reports.

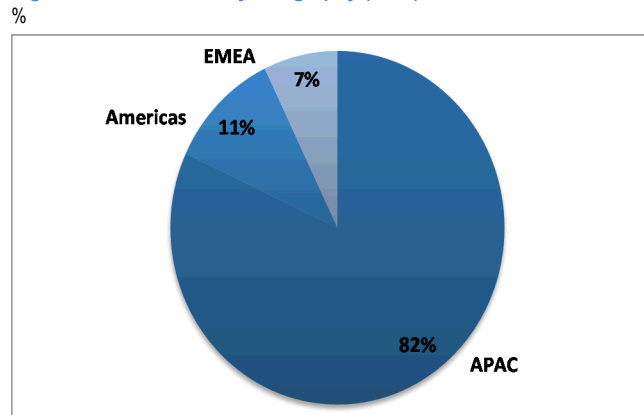**Figure 2: TER Historical Revenue Mix (2015-2021)**
%
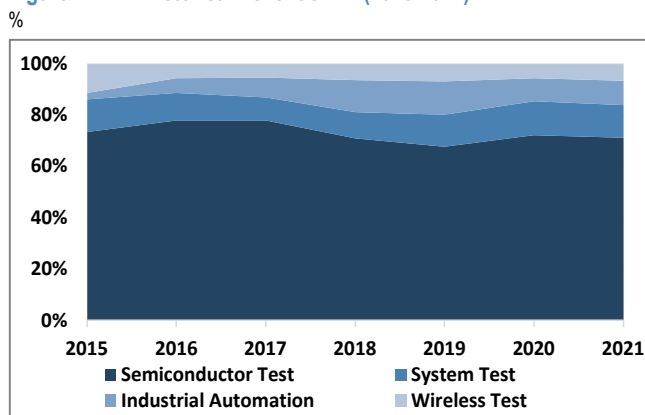
Source: Company reports.

Geographic mix heavily weighted to APAC, driven by foundry/OSAT customers

As shown in Figure 3, below, Teradyne's revenue mix by geographic region is heavily weighted toward Asia-Pacific, which accounts for 82% of revenue, followed by the Americas (11%) and EMEA (7%). Taiwan, Korea, and China account for a majority of sales, altogether comprising 61% of total revenue in 2021, reflecting the concentration of foundry and OSAT customers in Asia.

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North America Equity Research
05 July 2022

J.P.Morgan

**Figure 3: Revenue Mix by Geography (2021)**

%

Source: Company reports.

Top 5 direct customers, including TSMC, are quite concentrated

Teradyne sells test systems to OSAT and foundry customers, including, for example, TSMC, which accounted for 12% and 15% of total revenue in 2021 and 2020, respectively. Teradyne's customer concentration is quite high, with its five largest direct customers accounting for 33% and 36% of total revenues in 2021 and 2020, respectively.

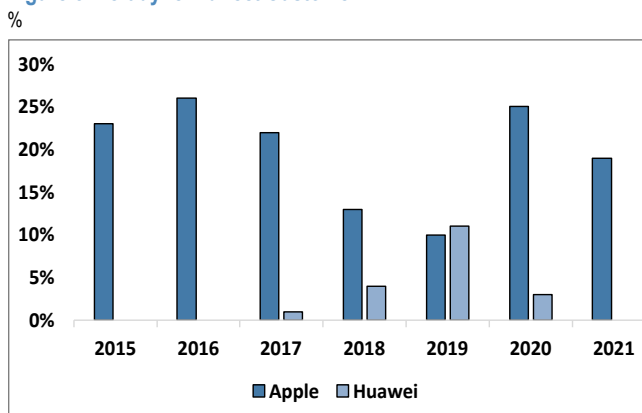**Figure 4: Teradyne Customer Concentration (2021)**

%
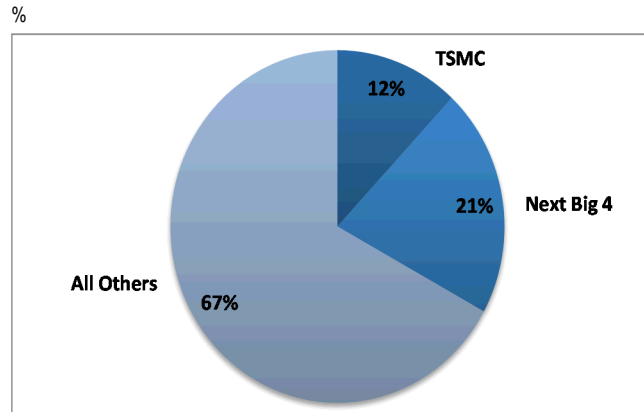
Source: Company reports.

Apple indirectly drives ~20-25% of revenue, partly in representation of Teradyne's broad exposure to testing for the smartphone industry

While foundry/OSATs are Teradyne's direct customers, indirect customers (OEMs) drive much of the revenue, including major smartphone companies, which recommend certain test systems for their devices. Teradyne estimates that Apple has driven about 19% and 25% of total revenue in 2021 and 2020, respectively. Separately, Huawei drove ~11% of total revenue in 2019, though following U.S. sanctions against Huawei, Teradyne currently derives no revenue from Huawei.

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North America Equity Research
05 July 2022

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Figure 5: Teradyne Indirect Customer Mix

%

Source: Company reports.

Other large customers include Broadcom, Samsung, and Qualcomm, although company is actively diversifying from exposure to the smartphone market

Outside of Apple driving 20-25% of revenue for Teradyne, the company also supplies test equipment to other large chip manufacturers, including Broadcom, Samsung, and Qualcomm. Meanwhile, Teradyne does not have a footprint with AMD, Intel, and NVIDIA, as the company does not test x86 processors and GPUs and competitors are very difficult to displace due to the stickiness of the installed base with other test equipment providers.

Table 1: Customer Footprint for Teradyne

Single sourced	Large share	Some share	No share
Apple	Broadcom	Qualcomm	AMD
	Samsung	Mediatek	Intel
			NVIDIA

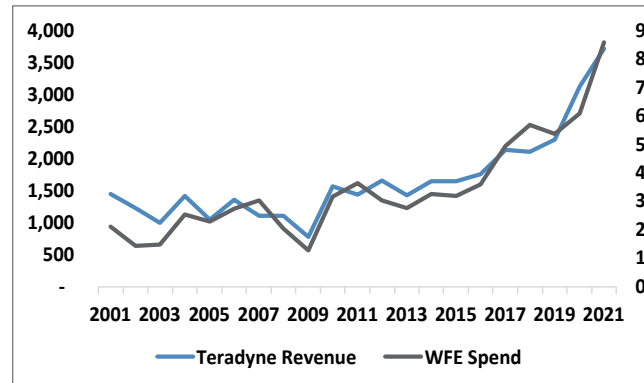Source: Company reports and J.P. Morgan estimates.

Additionally, Teradyne has been active in diversifying away from the smartphone end market into compute, and aims to become a major test supplier for hyperscalers and other cloud customers, including Microsoft, Meta, Google, and Tencent.

Teradyne revenue has been historically correlated with WFE spend; forecast WFE spend to expand by double-digits in 2022 and 2023

Teradyne directly sells equipment to foundry partners for production stage testing and with wafer fab equipment (WFE) being a good leading indicator of fab capacity for semiconductor manufacturing, it is unsurprising to find that Teradyne's revenue is highly correlated with wafer fab equipment (WFE) spend. As shown in Figure 6, Teradyne's revenues have been strongly correlated to WFE spend historically.

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North America Equity Research
05 July 2022

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Figure 6: Teradyne Revenue vs. Global WFE Spend
$ in Millions on Left, $ in Billions on Right

Source: Company reports and J.P. Morgan estimates.

Our J.P. Morgan Semiconductor Capital Spending Model (maintained by JPM Semiconductors & Semiconductor Capital Equipment / IT Hardware analyst Harlan Sur) forecasts WFE spend to remain robust at 17% growth in 2022, and moderate, yet remain robust, at 10% growth in 2023. Demand for semiconductors will continue to drive demand for capacity expansion and hence demand for test equipment supporting production, providing a robust spending backdrop for Teradyne in the medium term.

Figure 7: WFE Spend Forecasts
$ in Billions, %
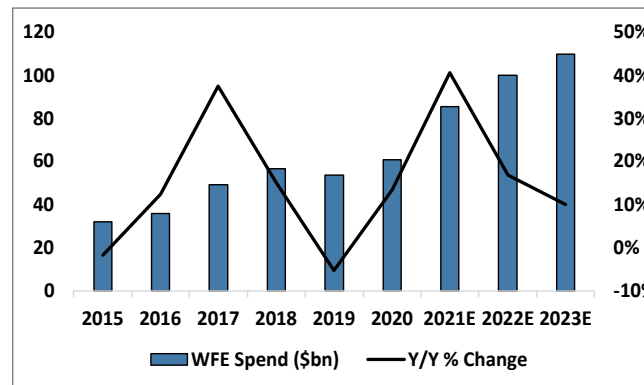
Source: J.P. Morgan estimates.

Competitive landscape is fragmented outside of Semiconductor Test

Teradyne's exposure to various types of Test & Measurement markets and its growing presence in Industrial Automation (no testing overlap) imply that it has a broad set of competitors.

That said, Teradyne's core market of semiconductor test is quite consolidated with Advantest as the other primary player and Cohu amongst the smaller participants. However, beyond Semiconductor test, the market remains fragmented with competition from Keysight, National Instruments, Rohde & Schwarz, and Anritsu in the broad test and measurement markets, as well as with traditional industrial robot manufacturers as well as start-ups in the collaborative robot / autonomous mobile robot space.

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North America Equity Research
05 July 2022

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Table 2: Teradyne Competitors by Segment

Segment	Competitors
Semiconductor Test	Advantest, Cohu
System Test	Keysight, Advantest, Test Research Inc., SPEA
Wireless Test	Rohde & Schwarz, Anritsu, Keysight, National Instruments, Welzek, iTest
Industrial Automation	Omron, KUKA, ABB, FANUC, Yaskawa, Techman, Doosan, AUBO Robotics, Fetch, OTTO Motors, Vecna, Seegrid, Balyo

Source: Company reports.

Semiconductor Test Is the Primary Engine for Teradyne

Multiple platforms serve smartphone, compute, industrial and auto end markets

IDMs (Integrated Device Manufacturers) – design and manufacture ICs (e.g., Intel, Samsung)

Fabless – design ICs but outsource manufacturing (no fabrication facility) (e.g., Qualcomm, Nvidia, AMD)

Foundry – do not design ICs, focused on manufacturing ICs (e.g., TSMC, GlobalFoundries)

OSAT (Outsourced Semiconductor Assembly and Test) – third-party vendors that assemble, package, and test ICs (e.g., ASE Technology, Amkor)

Teradyne provides test systems for both wafer level and device package testing, and sells systems to IDMs (Integrated Device Manufacturers), fabless companies, foundries, and OSATs in the supply chain. As shown in Table 3, below, Teradyne has developed multiple platforms to address the quality and efficiency needs of its customers, with the top priority being "Cost of Test" economics, i.e., minimizing cost per unit through parallel testing of thousands of units simultaneously.
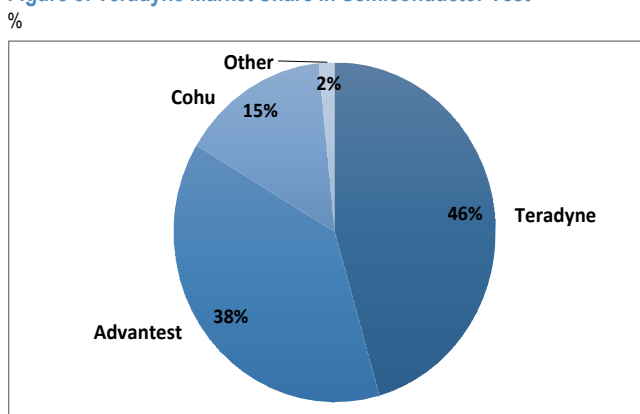
Table 3: Teradyne's Semiconductor Test Platforms

Platform	Function
FLEX & UltraFLEX	Core platform; multi-site (parallel) testing for wide range of devices; uses IG-XL software OS
J750	Tests highest volume semiconductor devices (e.g. microcontrollers); uses IG-XL software OS
IP750	Tests image sensor devices in smartphones, autos, etc.
Magnum	Flash and DRAM memory test
Eagle Test (ETS)	Tests cost-sensitive applications primarily in analog/mixed signal markets; weighted to Autos

Source: Company reports.

Leader in Semiconductor Test with nearly half of market share

Semiconductor Test, which drives 70% of Teradyne's business, is largely a two-player market, with Teradyne and Advantest comprising more than 80% of Semiconductor Test, as shown in the figure below. We view this market concentration constructively, as it enables 1) Teradyne's position with its customers to be very "sticky"; 2) market consolidation over time allowing Teradyne to solidify its leading position; and 3) pricing power leveraging its leadership position allowing for gross margin expansion over time.

Figure 8: Teradyne Market Share in Semiconductor Test
%

Source: Company reports.

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Semiconductor Test includes SoC Test and Memory Test

Teradyne bifurcates its Semiconductor Test segment into:

1) System-on-a-Chip (SoC) Test – which parallel tests standard chips for a variety of end markets. Teradyne expects the market opportunity for SOC Test to expand to $5 bn by end of 2022, representing a +13% CAGR from 2016 to 2022E.

2) Memory tests in which Teradyne tests both DRAM and NAND devices. Teradyne expects the market opportunity for memory tests to remain flat y/y in 2022 at $1 bn, although with a robust growth CAGR of +16% long term from 2016 to 2022E

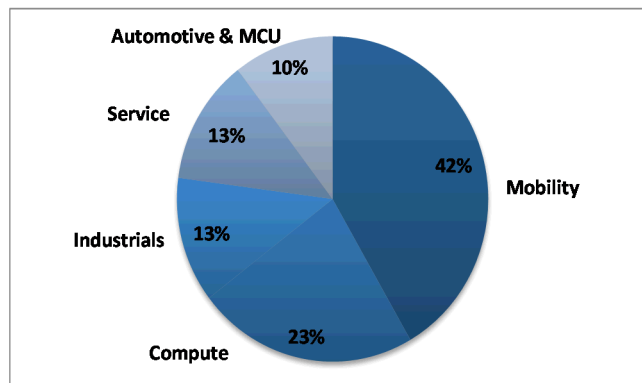**Figure 9: SoC and Memory Test TAMs**

$ in Billions
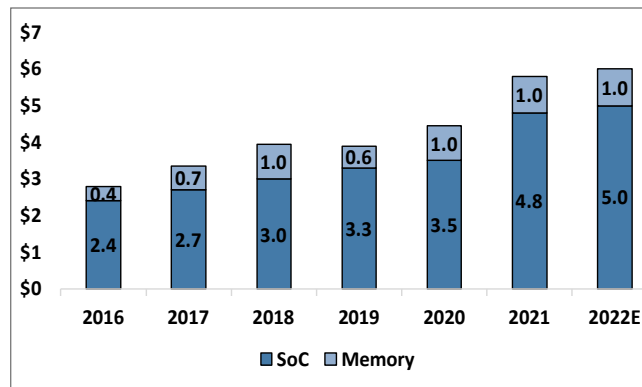
Source: Company reports.

In SOC, Mobility is mature and the growth opportunities pertain to Compute & Automotive, and Industrials

Within the SoC test market, Teradyne supplies into the handset (mobility), compute, automotive, and industrial end markets. Mobility is the largest but most mature end market, while compute and automotive end markets have the highest growth potential. As shown in the figure below, nearly half of the SOC market was accounted for by Mobility in 2021.

Figure 10: SoC End-Market Exposure (2021)

%

Source: Company reports.

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While the Mobility SOC market is the largest overall opportunity, the growth opportunities relate more specifically to smaller SOC test areas of Compute, Automotive & MCUs, and Industrials.

More specifically, the company noted strong demand for testing network processors, server chips, and other communication gear (not CPUs) to support high-performance Compute requirements at hyperscalers, such as Microsoft, Facebook, Google and Tencent. Teradyne expects the Compute end market for SOC testing to expand from $0.6 bn in 2020 to $1.4 bn in 2022, at a rapid +53% CAGR.

On the Automotive side, consistent with comments from Keysight and National Instruments, Teradyne points to the test requirements for ADAS applications as a major driver of growth, estimating that high-end ADAS processors have 3-4x longer test times. The company expects the Automotive & MCU market to expand from $0.3 bn in 2020 to $0.6 bn in 2022.

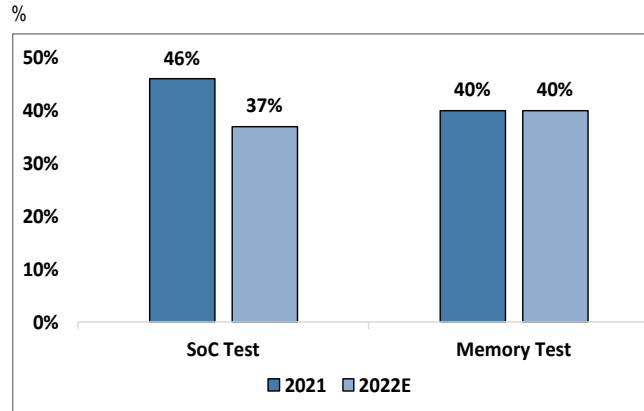**Figure 11: SoC Test End-Market TAMs**
$ in Billions
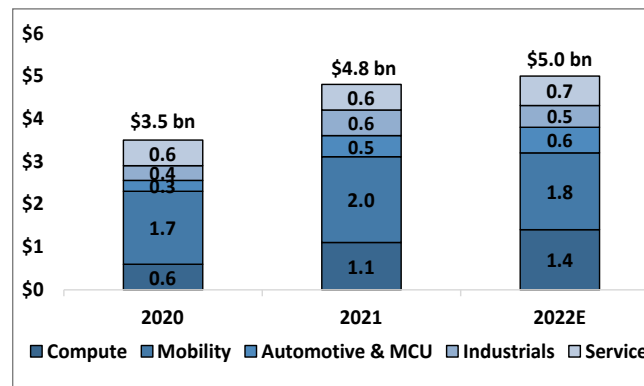
Source: Company reports.

Market share in SOC should track lower than typical near term on account of unfavorable customer mix

Teradyne comprises about 50% of the SoC test market and 40% of the memory test market. That said, its market share can fluctuate from year to year depending on end customers' investment cycles; for example, Teradyne expects its share in Semi Test will trend around 37% (vs. 46% in 2021) given customer mix for which TSMC (a customer of Teradyne) plans to ramp testing of its 3 nm node in late 2022, while Intel and AMD (which are not customers of Teradyne) are in the middle of large investment cycles. In the near term on account of current customer mix, Advantest, a key competitor to Teradyne, is likely to do better in relation to market share without any displacement of Teradyne wins.

Similarly, memory test market share can vary in the near term depending on the mix of DRAM and NAND flash.

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Figure 12: SoC Test and Memory Test Share
%

Source: Company reports.

Within the memory test market, Teradyne has disclosed that its share within the NAND flash market is ~60%, and share within the DRAM market is ~30%. For 2022, Teradyne currently estimates that the market is about 60/40 DRAM/NAND (vs. an estimated 70/30 mix in January), which is incrementally more positive for Teradyne, though capacity constraints are impacting Memory Test growth as shown in Figure 9, above.

Figure 13: Teradyne Memory Test Market Share
%
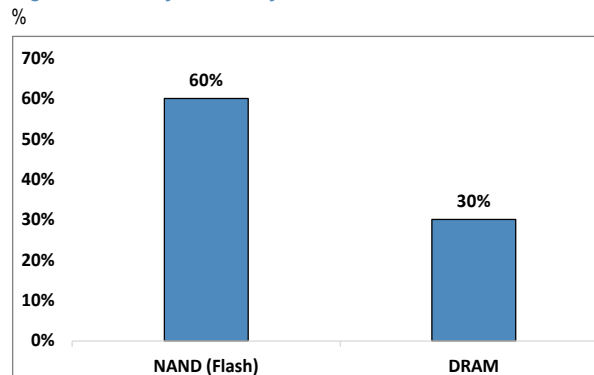
Source: Company reports.

Growth driver remains complexity and production volumes, leading to leverage to node transitions

Across the different end markets outlined above, including mature and emerging end markets, the biggest driver of revenue increases is complexity and volumes. In addition to the cyclicality introduced by semiconductor volume demand, particularly in end markets like mobility, Teradyne's revenues have additional leverage to node transitions for semiconductor manufacturing that should lead to a step-level change in complexity, overwhelming near-term volume dynamics in the end markets, and driving higher revenue opportunities. Node transitions drive growth in complexity and higher transistor densities, and thus require increased time for testing before more normalized volumes are reached. The company estimates that for every "rough jump" of 30-40% in transistor count, tester capacity jumps ~20%.

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As shown in Figure 14, below, revenue tends to peak in 3-year increments during the year of node transition, except for the most recent transition in 2020/21/22 due to strength in 5G smartphone volumes, as well as growth in compute, industrial, and automotive markets.

Figure 14: Teradyne Semiconductor Test Revenue
$ in millions
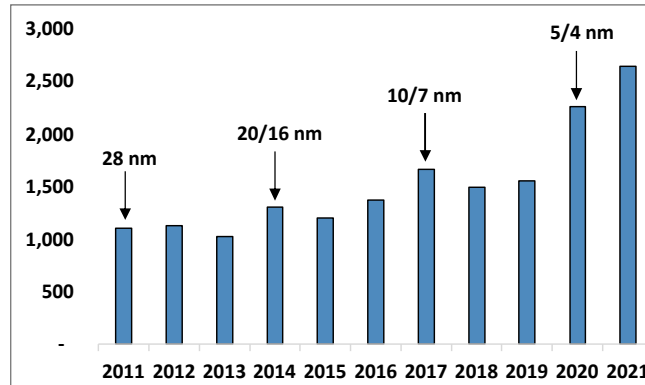
Source: Company reports.

Expect 3 nm node transition to drive next upcycle in 2023

TSMC expects the transition to the next leading-edge node, 3 nm, to ramp beginning in 2H22 and is likely to be present in the launches of iPad and iPhone in 2023 (iPhone 15 cycle). Samsung, another large customer, is also expected to migrate to 3 nm after Apple around 2024, while hyperscaler customers are typically n-1 nodes behind and thus would be expected to transition to 3 nm in ~2025.

When aggregating Teradyne's roadmap, the above suggests a peak in relation to Mobility end markets in 2023 and a moderate down-cycle beyond 2023 with elongated timing around 3 nm transition and deployment, although we would expect to continue to see growth in other end markets beyond mobility.

Gate-all-around architecture transition is another upside driver

Separate from the 3 nm node transition, another upcoming change in transistor architecture is from FinFET to gate-all-around (GAA) – which is a longer cycle transition typically occurring once every decade relative to a much faster transition in nodes.

The prior transition from Planar architecture to FinFET played an important role in the test market's return to growth in 2012/13/14, offsetting the impact of adoption of parallel testing, and Teradyne sees an inflection point with the introduction of gate-all-around architecture, as each architecture change typically introduces additional failure modes that have greater testing requirements and testing time before the architecture matures.

Samsung is currently working on GAA architecture, with the earliest possible introduction in 2024, while TSMC is expected to transition to GAA architecture in late 2025 with its 2 nm node transition.

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Figure 15: Transistor Architecture Transition
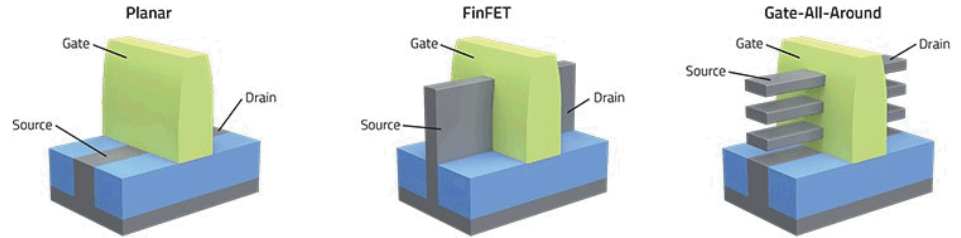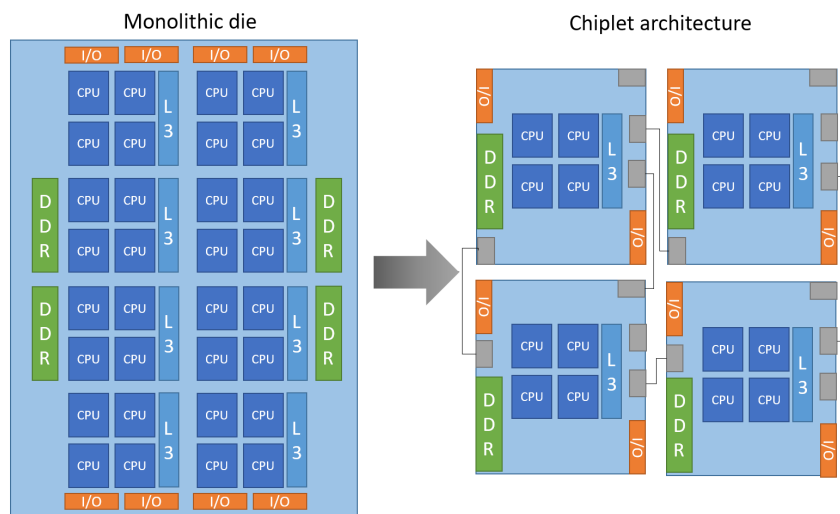

Source: Lam Research Blog (link)

Slower growth driver from unit volume increase, although could be cyclical for certain end markets near term

Aside from the upcoming transitions to 3 nm nodes and GAA architecture, another growth driver is semiconductor volumes, which Teradyne forecasts to remain in the high-single-digit percentages long term. However, that said, while we don't necessarily disagree with Teradyne's outlook for high-single-digit growth long term, we expect to see pronounced cyclicality in certain end markets associated with increasing frequency of node transitions and other technology changes.

Potential outsized opportunities relate to technology changes, including chiplets

Highest performance chip designs among AMD, Intel, Nvidia, and Broadcom have begun migrating to heterogeneous advanced packaging architectures, allowing "mix-and-match" of different types of smaller chips ("chiplets") in a package, as opposed to a traditional system-on-a-chip design. As one chip gets broken up into multiple smaller chiplets, individual chiplets might be tested by new entrants such as Teradyne, which could open a window for Teradyne to begin establishing a footprint with Compute customers like Intel and AMD, which are not currently customers of Teradyne. Furthermore, OEMs must conduct both wafer level tests on individual chiplets as well as test the package as a whole to validate interconnect and failure mechanisms, thus increasing the total test time as a whole relative to SoC architectures, which is another tailwind for Test companies.

Figure 16: Migration to Chiplet Architecture

Source: J.P. Morgan.

16

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For Memory Test, the main driver is the upcoming multi-year DDR5/LPDDR5 transition

DDR5 SDRAM is a type of synchronous dynamic random-access memory, which compared with its previous-generation DDR4 SDRAM chip represents a material reduction in power consumption, while increasing bandwidth. DDR5 and its low-power counterpart LPDDR5 represent another step-function improvement in performance by increasing bandwidth while lowering power consumption.

The transition to DDR5 also represents an increase in complexity. For example, in DDR4 and below, error-correction capabilities typically were not on the chip, but they are now integrated into the DRAM chip itself, which has increased the chip size and introduced additional complexity. As a result, memory test requirements are greater, which should benefit Teradyne's Memory Test platform; we believe the multi-year migration should support steady single-digit growth in Memory Test.

DDR5 should be supported in recent launches by major semiconductor companies, including Intel, AMD, and Samsung. For example, on the PC client side, Intel began to leverage DDR5/LPDDR5 on its Alder Lake platform in 2H21, and will also support DDR5 on its next-gen Meteor Lake platform beginning in 2H22; AMD also plans to roll out a next-gen PC processor platform that supports DDR5 in 2H22. On the server side, both Intel and AMD are preparing to ramp server microprocessors that support DDR5 beginning in 2023.

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System Test and Wireless Test Round Out Test Portfolio

In addition to the Semiconductor Test business at the component levels, Teradyne has leverage to System Test, led by its Storage Test business, as well as Wireless Test (also known as LitePoint). In combination, System Test and Wireless Test make up nearly 20% of total revenue, and we expect low- to mid-single-digit growth in both businesses over the long term, with Wireless Test outpacing System Test.

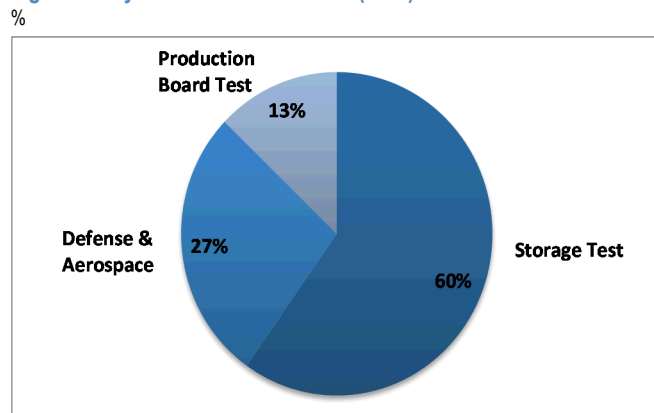**System Test is comprised of 3 units, led by Storage Test**

Teradyne's System Test segment is comprised of:

(1) Storage Test: HDD testing and semiconductor production (testing after wafer and package tests). HDD test is levered to PCs and external HDD storage products, including enterprise storage used in data centers and cloud storage. Semiconductor production test is levered to 5G smartphones and other 5G devices.

(2) Defense/Aerospace: tests military and commercial aerospace electronics systems, and is driven by new programs (e.g., tactical aircraft and missile systems) as well as program upgrades. Teradyne is a legacy vendor to major Department of Defense and international defense programs, as are Keysight and National Instruments in our coverage.

(3) Production Board Test (PBT): performs In-Circuit-Test (ICT) and device programming of printed circuit board assemblies.

As shown in Figure 17, below, of the three segments,

1. Storage Test is the largest of the three, and was also a major driver of outsized revenue growth beginning in 2019, which saw a proliferation in exabyte-level storage requirements, as well as an emerging need to test semiconductors at a system level for 5G smartphones.

2. Additionally, we expect Defense & Aerospace test to outpace its typical run-rate on account of increasing geopolitical uncertainty leading to greater defense spending.
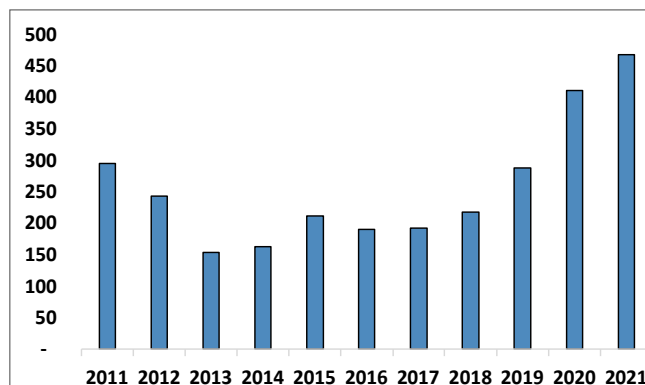
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Figure 17: System Test Revenue Mix (2021)
%

Source: Company reports.

Figure 18: Teradyne System Test Revenue
$ in Millions

Source: Company reports.

Wireless Test addresses Wi-fi, Cellular, Ultra-wideband, and Bluetooth

Teradyne acquired LitePoint in 2011, forming its Wireless Test business, which provides hardware and software wireless test solutions from design verification to high-volume production for smartphone, tablet, PC, peripherals, and IoT manufacturers. As such, the business unit is primarily levered to handset testing in the production stage, though it also tests Wi-Fi, Bluetooth, and GPS devices. Competitors include Rohde and Schwarz as well as Anritsu, while companies like Keysight are more focused on early-stage testing in R&D rather than production.

Figure 19: Teradyne Wireless Test Revenue
$ in Millions
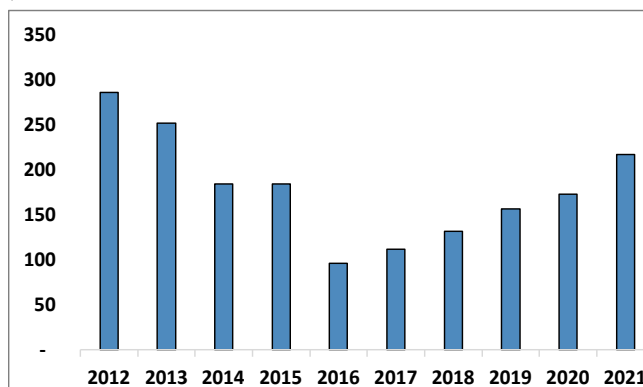
Source: Company reports.

In 2015-16, Teradyne took a large goodwill write-down as many customers figured out how to increase productivity in testing wireless connectivity features, which also was a major driver of Keysight exiting the system business. However, following the setback, Teradyne has been able to steadily grow its Wireless Test business through leverage to multiple independent test cycles in Wi-fi and cellular standards, while ultra-wideband has become a more meaningful revenue opportunity in the past two years.

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Industrial Automation Is a Rapidly Scaling Non-Test Business, Diversifying TER Beyond Cyclical Transitions

Teradyne built out Industrial Automation via series of acquisitions

In 2015, Teradyne began to build out its Industrial Automation (IA) segment, which serves manufacturing, warehouse, and logistics industrial end markets through deploying both fixed collaborative robots ("cobots") and autonomous mobile robots ("AMRs"). As shown in Table 4, below, Teradyne first acquired Universal Robots, its largest sub-unit, to gain exposure in cobots before expanding into AMRs with the acquisitions of Mobile Industrial Robots and AutoGuide.

Table 4: Industrial Automation Acquisitions

Name	Acquired	Value	Description
Universal Robots (UR)	May-15	$285 mn	Collaborative robots ("cobots") which work side by side with humans; low cost, easy to deploy
Energid	Feb-18	$28 mn	Software environment that programs motion of robot
Mobile Industrial Robots (MiR)	Apr-18	$147 mn	Autonomous mobile robots (AMRs) which move point to point via autonomous navigation; low cost, easy to deploy
AutoGuide	Oct-19	$58 mn	High-payload AMRs that are used in heavy material transport; complements MiR

Source: Company reports.

Cobots and AMRs serve different use cases

Cobots, or collaborative robots, are fixed at a station and work alongside humans in close proximity completing repetitive tasks at a rapid rate. Cobots can work on an assembly line for manual, standardized tasks, either in sequential collaboration (human followed by robot, or vice versa) or in cooperation (working on the same task). Cobots can also be outfitted with grippers, such as soft grippers for delicate tasks, or magnetic/vacuum grippers for tasks involving hazardous or difficult to handle materials. Cobots are also space efficient, reprogrammable, and come with built-in safety features, as opposed to traditional robots that tend to be bulky and difficult to reprogram.

Figure 20: Example of Cobots

Source: Company reports.

AMRs, or autonomous mobile robots, use sensors, AI/ML, and path planning to interpret and navigate through an environment autonomously, unconnected from wired power. Compared with their predecessors, autonomous guided vehicles (AGVs), AMRs are able to avoid unexpected obstacles, reroute, and continue their task without operator oversight. Depending on the model, AMRs can handle payloads ranging from 100 kg to 4,500 kg in warehouse and logistics applications.

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Figure 21: Example of AMR

Source: Company reports.

Driving strong double-digit growth through secular shift to automation, attractive economics, and low penetration
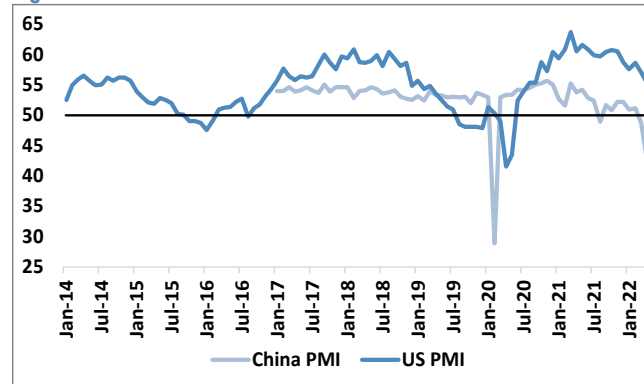
While IA currently comprises ~10% of Teradyne's sales mix, the company forecasts ~32-45% revenue CAGR (off the 2020-21 average IA revenue) for the segment relative to high-single- to low-double-digit growth in Test revenue, making IA a compelling growth opportunity. Driving this growth is:

1) a secular shift to "Industry 4.0," in which automation is an alternative to labor due to the lack of availability of labor, costs associated with turnover, and decreasing cost effectiveness of offshore labor;

2) short ROIs, averaging one year or less in payback time, making the investment attractive in a scarce labor environment;

3) penetration of <3% of the available ~$500 bn market for "automatable" tasks, suggesting a decades-long runway for growth in IA.

That said, IA is still levered to manufacturing cycles

The market for Industrial Automation is largely dependent on the pace of adoption of new automation technologies by manufacturers, and thus is generally correlated with manufacturing expansions and contractions, which accounts for the slowdown in revenue growth in 2019-20. Teradyne tracks PMIs as an indicator for IA demand, and while PMI currently indicates an expansionary cycle in the US, PMI for China has been more negative, suggesting near-term weakness in IA linked to macro uncertainty. That said, Teradyne estimates that only ~10% of its IA business is linked to China, leaving its current projections of 35+% growth in 2022 mostly unaffected.

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Figure 22: US and China PMI

Source: Bloomberg Finance L.P.

Leading market share in cobots, while AMR share is more fragmented

Teradyne is the market leader by a wide margin in cobots, tracking at ~45% market share, while the next largest player, Omron, has about 10-12% share, followed by a long tail of players. However, in AMRs, Omron is the market leader with ~9% of share, followed closely by Teradyne at ~7-8% share and other players tracking at ~6% share.

Figure 23: Teradyne's Market Share in IA
%
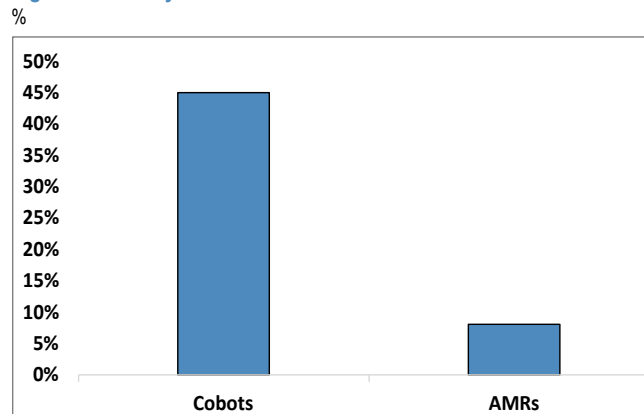
Source: Company reports.

Within IA, Universal Robots (UR) produces cobots, and Mobile Industrial Robots (MiR) produces autonomous mobile robots (AMRs)

Revenue has grown +44% CAGR since IA was established, driven mostly by Universal Robots

As shown in Figure 24, below, IA revenue has grown at a +44% CAGR since Teradyne first purchased Universal Robots, and helped by the acquisition of Mobile Industrial Robots in 2018. While the segment experienced some weakness in 2019-20 due to a manufacturing slowdown, IA revenue bounced back in 2021, growing +34% y/y, with most of the revenue contribution coming from UR. Management is optimistic in driving a +32-45% revenue CAGR through 2024 assuming no new acquisitions, with supply chain dynamics determining the range of top-line growth.

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Figure 24: Teradyne Industrial Automation Revenue
$ in Millions
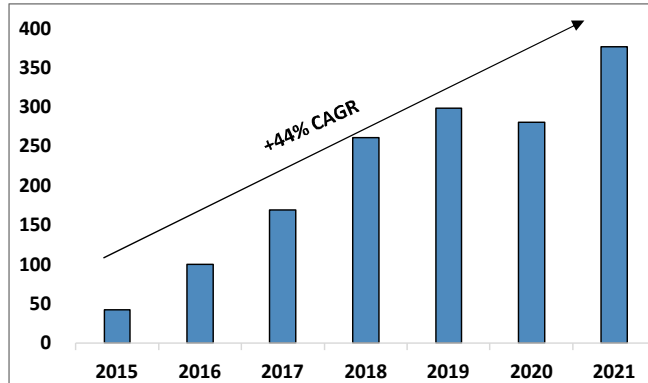
Source: Company reports.

Figure 25: IA Revenue Breakdown
%
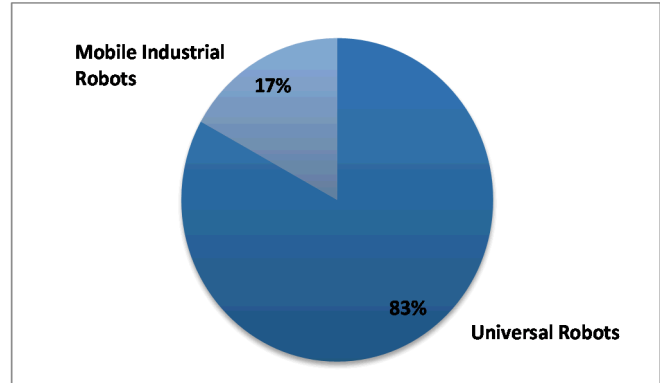
Source: Company reports.

Dilutive to operating margins due to investment required

While IA gross margins are slightly accretive to overall gross margins, trending slightly above 60%, operating margins for IA are much lower than the average operating margins for the Test portion for the business on account of Teradyne's ongoing investments in scaling and developing the IA business. We expect IA to be dilutive to earnings for a few more years, with the company targeting IA operating margins of 5-15% by 2024, and we forecast gradual margin expansion in IA as the business scales and gains leverage.

Figure 26: Test vs. IA Operating Margin (2021)
%
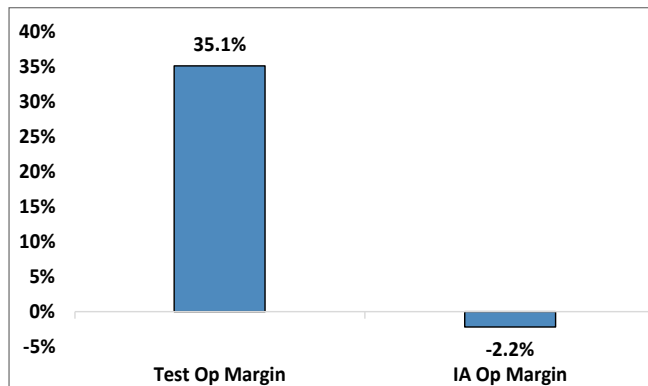
Source: Company reports.

Figure 27: IA Operating Margin Historicals and Forecast
%

Source: Company reports and J.P. Morgan estimates.

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Financial Outlook

Past revenue performance is mixed but still equates to high-single-digit growth on the top line

As shown in Figure 28, below, Teradyne's revenue performance has been far from consistent in relation to growth for much of the company's history, due to the company's leverage to semiconductor test, which has gone through multiple cycles of growth and declines based on node transitions, productivity improvements, and new architectures.

However, Teradyne saw a material ramp in revenue in 2020-21, as the company was favorably positioned to multiple tailwinds, most notably Apple's rollout of a 5G smartphone, which boosted wafer, system, and device tests in Semiconductor, System, and Wireless test segments; furthermore, Teradyne benefited from tailwinds with other 5G smartphones, ramping hyperscaler demand for high-performance compute, ADAS processor testing, and exabyte-level storage needs.

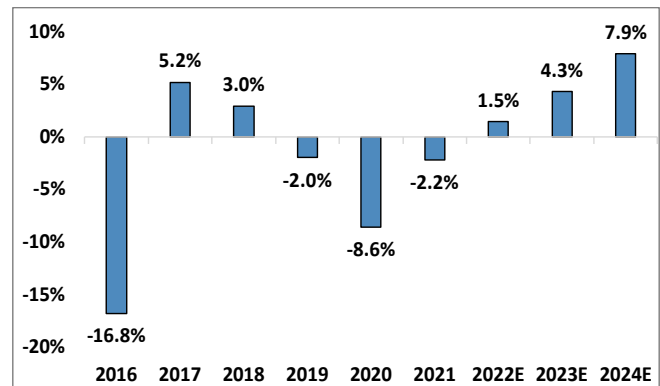Putting the cyclicality of the business aside, on a longer-term basis, Teradyne's revenues have expanded at a 7% CAGR, representing the growth opportunities for Teradyne in the underlying markets, although not linear in every aspect.

Figure 28: Teradyne Revenue Performance
$ in Millions
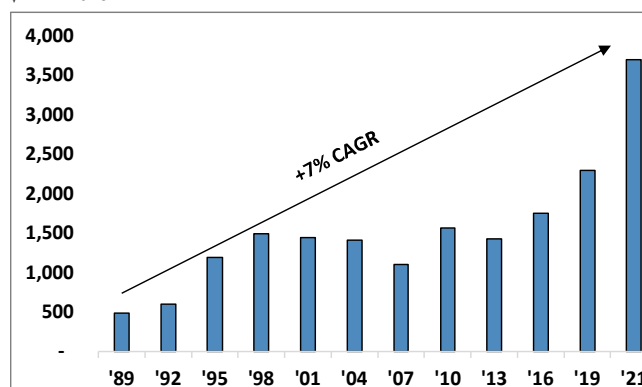
Source: Company reports.

Forecast similar growth trajectory through to FY24, although led by IA at dilutive margins

As outlined in the figure below, we model FY21-FY24 revenue CAGR to track at around 7%, fairly similar to the long-term growth rate we have seen for Teradyne, although with the following underlying pieces:

1. Near-term peak revenue growth of +24% y/y in FY23 on account of node transitions followed by much more modest growth in FY24 at the tail end of node migration

2. Growth in a mid-single-digit CAGR between FY21 and FY24 for Semiconductor Test, eclipsed by higher growth rates in Wireless Test, and in particular by high growth in Industrial Automation.

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Figure 29: Revenue Outlook
$ in Millions
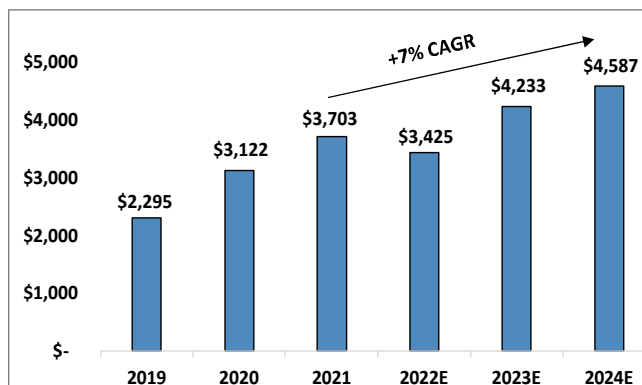
Source: Company reports and J.P. Morgan estimates.

Semiconductor growth to remain robust and cyclical, more modest growth in System; Industrial Automation growth to sustain at a high level

As discussed in the Semiconductor Test section of this report, Teradyne is a major beneficiary of several upcoming growth drivers over the next few years, including the transition to 3 nm nodes starting 2H22 and 2 nm nodes starting 2H25, FinFET to GAA architecture transition, and DDR5 memory transition driving our forecast for +5% CAGR between FY21 and FY24, although comprising in this case a -16% decline in FY22, and +28% growth in FY23, followed by a +5% increase in FY24.

Figure 30: Revenue CAGR by Segment (2021-2024E)
%
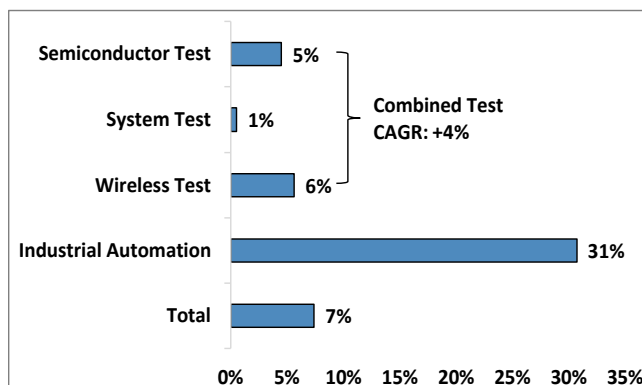
Source: Company reports and J.P. Morgan estimates.

Meanwhile, we forecast +1% and +6% CAGR in System and Wireless test, respectively, with System Test largely bereft of any inflections in content due to absence of technology transitions, and Wireless Test a modestly stronger growth area for Teradyne given relatively frequent upgrade cycles for Wi-fi as well as the new growth opportunity around UWB. The combined growth forecast of +4% CAGR across all three Test segments tracks at the low end of Teradyne's implied guidance for +4-8% total Test revenue CAGR from 2021 to 2024.

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Industrial Automation is the strongest growth opportunity

Relative to the mid- to high-single-digit revenue growth forecast, Industrial Automation revenues are expected to expand at a material double-digit pace; we forecast a +30% CAGR, led by the higher growth in a nascent and emerging market opportunity as well as increasing adoption of both stationary and mobile robots in industrial applications.

Gross margins to remain relatively stable around 60%

Teradyne historically trended at a mid-50s% gross margin; however, we expect the gross margins to be relatively stable around an improved 60% level, on account of : 1) improving product mix toward newer, higher-margin Test equipment as frequency of technology changes in key end markets increase; 2) market consolidation within Semiconductor test, which has narrowed to Teradyne and Advantest as the two main competitors, with both disciplined on pricing; and 3) expansion in the IA business, which has gross margins around 60%.

In the near term, the current supply and macro environment has been challenging for many hardware companies, but Teradyne has been successful in mitigating the impact on gross margins through multi-sourcing agreements, led by prior investments to reduce the bill-of-materials as well as price increases, and we foresee minimal impact on gross margins in 2022 relative to 2021.

Figure 31: Gross Margin Outlook
%
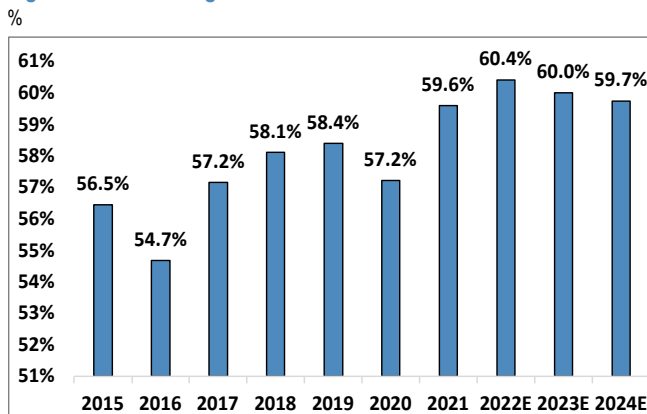
Source: Company reports and J.P. Morgan estimates.

Operating margin trend cyclical with revenue growth and node transitions

As test requirements and test times extend with increasing complexity over a longer time horizon, Teradyne is able to scale and gain operating leverage, which is reflected in the company's historical operating margins.

Looking back historically, it is unsurprising that Teradyne has a step-up in operating margins in the year of node transition given outsized revenue gains without any commensurate increase in opex; for example, in 2017, operating margins jumped from ~20% to mid-20s% with the 10/7 nm node transition, and in 2020, operating margins jumped to 30% with the 5 nm node transition. That said, margins have tended to either remain stable or moderate in years with relatively limited transition-led tailwinds, putting revenue growth under pressure and leading to operating deleverage.

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Figure 32: Operating Margins

%
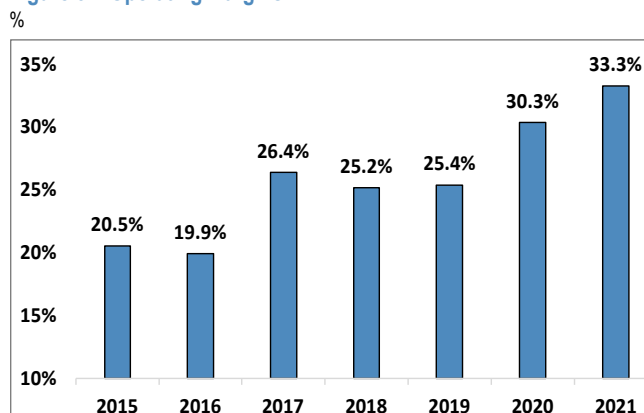
Source: Company reports and J.P. Morgan estimates.

Margins to remain choppy

Looking forward, Teradyne forecasts rising opex on both inflationary costs as well as R&D, and in conjunction with an expected revenue moderation in 2022, we forecast margin moderation as well.

However, we forecast margins to return to low-30s% with the 3 nm node transition in 2023 and slowing opex growth in the out years, which is in line with Teradyne's internal goal of 31-34% by 2024. It is important to highlight that our 2024 operating margin forecast remains below the 2021 figure on account of a higher run-rate of operating expense increase (10% CAGR) relative to a revenue CAGR of 7% over FY21 and FY24.

Figure 33: Operating Margin Outlook

%
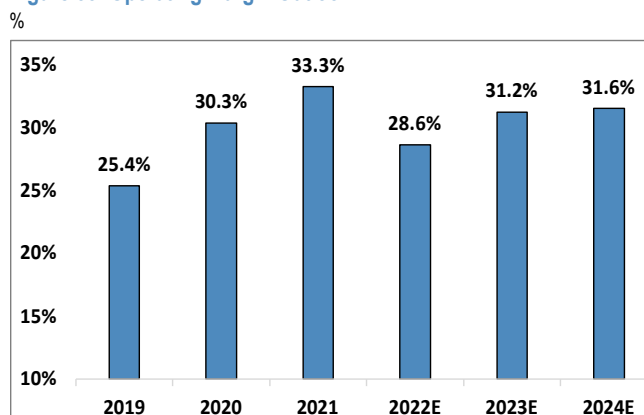
Source: Company reports and J.P. Morgan estimates.

EPS moderation in 2022 expected; long-term EPS CAGR in line with revenue growth

As shown in Figure 34, below, cycling past weakness in 2022 earnings, we believe Teradyne will demonstrate strong earnings growth in the coming years led by technology transitions as well as growing industry demand for Test equipment across various end markets and customers.

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However, on a long-term basis looking out to FY24, we forecast earnings CAGR to track in line with revenue growth, as margin moderation offsets accretion from buybacks.

Figure 34: EPS Outlook
$ per share
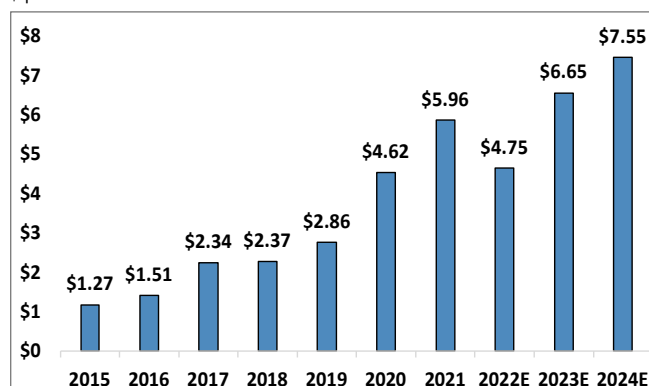
Source: Company reports and J.P. Morgan estimates.

Capital allocation priorities include organic investments and share repurchases

With over $1 bn in cash, cash equivalents, and marketable securities as of the last reporting period, and only a modest gross debt leverage, Teradyne has a strong balance sheet position.

Teradyne intends to use capital for share repurchases, dividends, and investment in both organic and inorganic growth. The company internally prefers M&A to buybacks, but only if the acquisitions can out-earn the ~11% cost of capital, which has led to relatively infrequent acquisitions, including its 2008 acquisition of Eagle Test Systems, the 2011 acquisition of LitePoint, and three acquisitions to build its Industrial Automation business.

However, in light of limited acquisitions in recent years and focus on organic growth investments, we expect Teradyne to use a significant part of the $2.6 bn of free cash flow that we forecast to be generated through FY22 to FY24 in share repurchases (JPMe $2 bn of repurchases through FY22-FY24).

Track record of exceeding revenue targets

Teradyne first introduced a long-term model, in this case for 2021, at the start of 2018 concurrent with 4Q17 earnings results, including key assumptions (e.g., underlying industry growth and IA growth). 2021 actuals far surpassed the original revenue targets due to the proliferation of devices requiring test equipment.

Table 5: 4Q17 Long-Term Earnings Model
$ in Millions, %

	2021 Target	2021 Actual
Revenue	$2,870-3,200	$3,703
Gross Margin	56-57%	59.6%
Opex %	30-31%	26.3%
Operating Margin	25-27%	33.3%
EPS	$3.50-4.00	$5.96

Source: Company reports.

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Teradyne then updated its long-term earnings model for 2022, once at the start of 2019 and once in 2020. As shown in Table 6, when 4Q19 results were reported, Teradyne widened the revenue range and increased the upper end of its target EPS, though the targets generally stayed consistent with the prior year. We expect 2022 revenue to surpass the high end of the last issued guidance range.

Table 6: 4Q18/4Q19 Long-Term Earnings Model

$ in Millions, %

	2022 Target (4Q18)	2022 Target (4Q19)	2022 JPMe
Revenue	$2,800-3,200	$2,700-3,250	$3,425
Gross Margin	57-58%	58-59%	60.4%
Opex %	31-32%	31-32%	31.8%
Operating Margin	25-27%	26-28%	28.6%
EPS	$3.50-4.00	$3.50-4.25	$4.75

Source: Company reports and J.P. Morgan estimates.

Most recently, Teradyne has issued a long-term model for 2024, which was last updated in January 2022. As shown in Table 7, the most recent 2024 targets were all improved upon, with the company expecting a ~10% revenue CAGR over 2021-24 at the midpoint of guidance.

We expect 2024 financials to track largely within the issued guidance range, although with one key difference – we expect revenues to track at the low end of the guidance range on account of a greater focus on test efficiency following a node transition as well as a slowdown in production test activity in a period of slower economic growth accompanied by moderation of the growth outlook in key consumer markets.

Table 7: 4Q20/4Q21 Long-Term Earnings Model

$ in Millions

	2024 Target (4Q20)	2024 Target (4Q21)	2024 JPMe
Revenue	$3,500-4,250	$4,600-5,250	$4,587
Gross Margin	58-59%	59-60%	59.7%
Opex %	28-29%	26-28%	28.2%
Operating Margin	30-31%	31-34%	31.6%
EPS	$5.25-6.75	$7.00-9.00	$7.55

Source: Company reports and J.P. Morgan estimates.

Though long-term targets are robust, cyclicality is still embedded

While we view Teradyne's current long-term targets as largely achievable, we also acknowledge that Teradyne is a cyclical business, as evidenced by the Street forecasting lower revenue in 2022 relative to 2021, even with Teradyne's diversification of customer base and leverage to an industrial upcycle. Because the company is still levered to a concentrated customer base, we recognize investors may be wary of potential downturns from year to year, and have factored the cyclicality into our valuation below.

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Teradyne Forecasts in a Snapshot

Figure 35: Revenue (2015-2024E)

$ in Millions
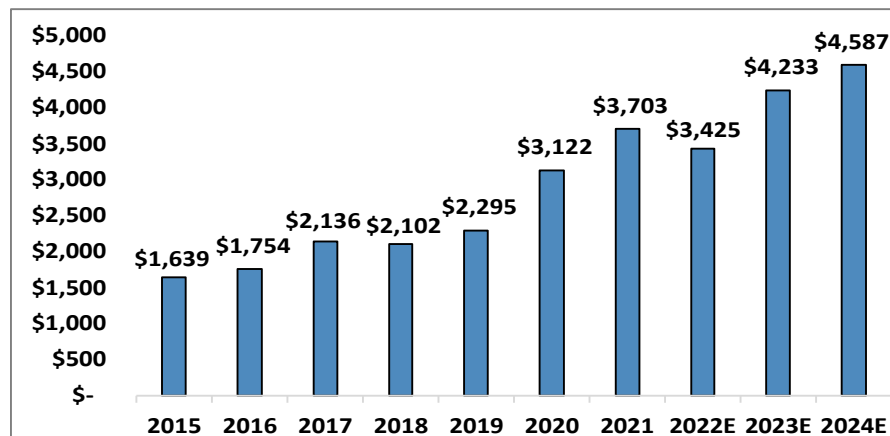
Source: Company reports and J.P. Morgan estimates.

Figure 36: EBIT (2015-2024E)

$ in Millions
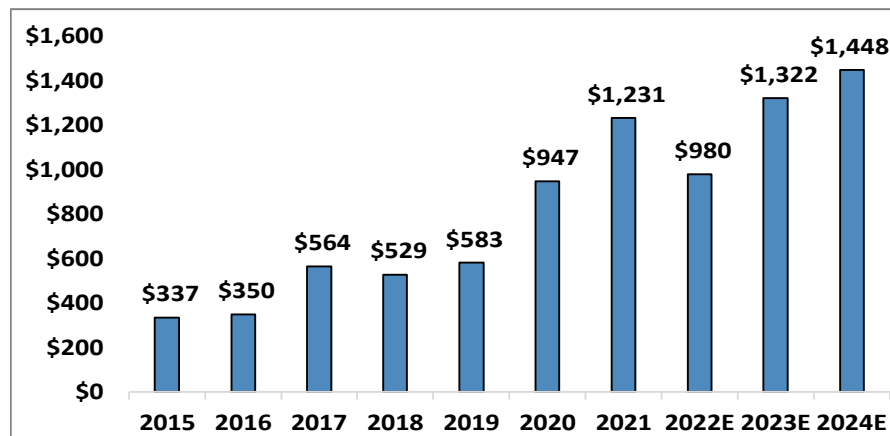
Source: Company reports and J.P. Morgan estimates.

Figure 37: EPS (2015-2024E)

$ per share
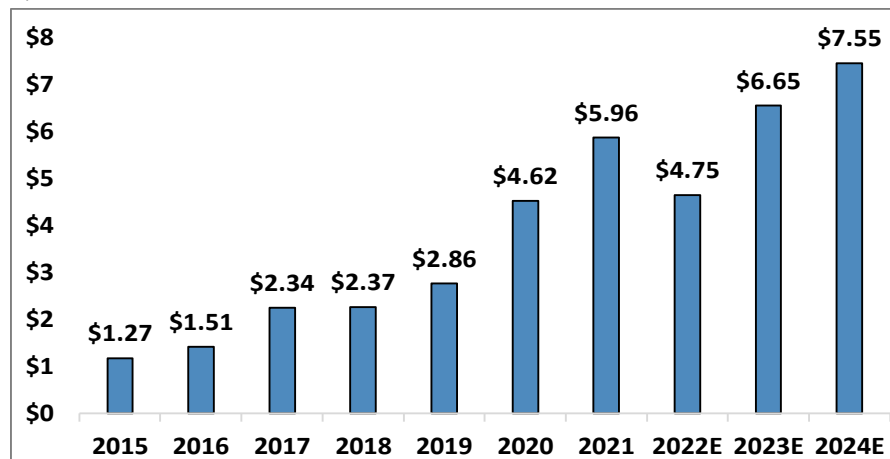
Source: Company reports and J.P. Morgan estimates.

Figure 38: FCF (2015-2024E)

$ in Millions
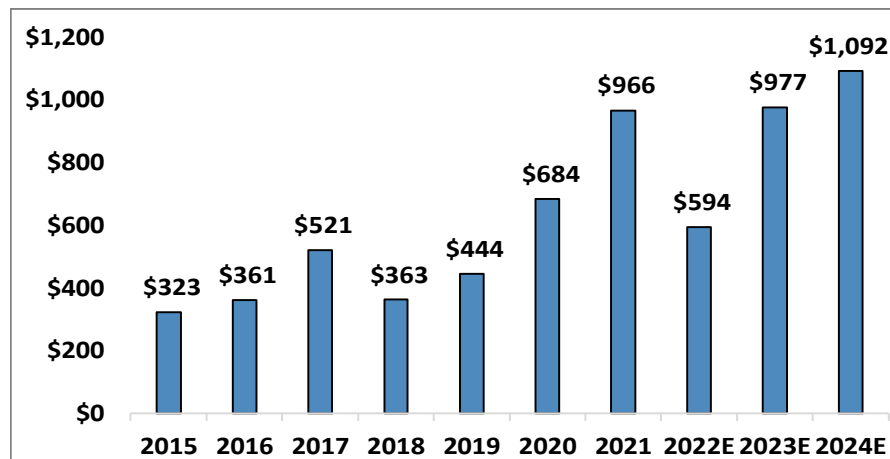
Source: Company reports and J.P. Morgan estimates.

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Valuation

We rate Teradyne shares Neutral with a Dec-22 price target of $120, implying +33% upside potential

We are introducing a December 2022 price target of $120 using an 18x P/E multiple on our CY23 EPS estimate of $6.65, which implies about 40% upside from current levels.

Table 8: Teradyne's P/E-Based Price Target

$ in Millions, except per share data

	NTM Qtrs 1-4	2023E
JPM Net Income	807	1089
JPM EPS	$4.75	$6.65
P/E Multiple	18.0x	
JPM P/E Multiple		18x
Implied Equity Value	15,057	19,596
Average Diluted Share Count	175	164
Implied Share Price	**$85.8**	**$120.0**
Current Value per Share	$85.80	$85.80
Upside vs. Current		40%
Memo:		
(-) Net Cash/(Debt)	1,168	1,261
Enterprise Value	13,889	18,335
JPM EBITDA	1,084	1,469
Implied EV/EBITDA	*12.8x*	*12.5x*

Source: Company reports and J.P. Morgan estimates. Note: Priced as of June 29, 2022.

While the 18x multiple is modestly below current trading levels, the multiple still represents a modest premium to other T&M companies, which we believe is justified given the robust top-line trajectory, industry-leading operating margins, and diversification into Industrial Automation.

However, we find the current NTM multiple is quite rich, even tracking above OW-rated Keysight, an industry leader in T&M more aligned to secular growth trends, whereas Teradyne by and large remains a cyclical growth company with closest competitor Advantest trading at a ~14x P/E (2022E).

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Table 9: Peer Comps Table

	Ticker	Analyst	Rating	Price	Price Target	FY22E P/E	FY23E P/E	FY19-23E Rev CAGR	FY19-23E EPS CAGR	FY23E Gross Margin	FY23E Op Margin
Teradyne	TER	Samik Chatterjee	N	$86	$120	18.1x	12.9x	17%	24%	60%	31%
National Instruments	NATI	Samik Chatterjee	N	$31	$42	14.8x	12.4x	8%	11%	74%	21%
Keysight	KEYS	Samik Chatterjee	OW	$136	$200	19.0x	17.4x	7%	14%	66%	29%
Viavi	VIAV	Samik Chatterjee	N	$13	$18	14.1x	13.2x	5%	9%	63%	23%
Advantest	6857 JT	Junya Ayada	N	¥7,060	¥9,450	12.4x	12.8x	17%	22%	58%	30%
Anritsu	6754 JT	N/A	NC	¥1,473	N/A	13.5x	11.7x	4%	12%	53%	18%
Average (ex-TER)						**14.8x**	**13.5x**	**8%**	**14%**	**63%**	**24%**

Source: Company reports, J.P. Morgan estimates for TER, NATI, KEYS, VIAV, Advantest; Bloomberg Finance L.P. consensus estimates for Anritsu.

Note: Last priced for July 1. All price targets are December 2022 price targets.

As shown in the figure below, TER shares have traded at a 20x P/E multiple, which we believe is tough to justify given cyclicality around timing of the technology transitions. For reference, the long-term P/E multiple for secular growth Keysight is 20x, and for more cyclical Advantest and National Instruments, both have historically tracked at 22x though have recently traded down to a mid-teens P/E, which we view as a fairer valuation.

Figure 39: TER Historical P/E Multiple

x
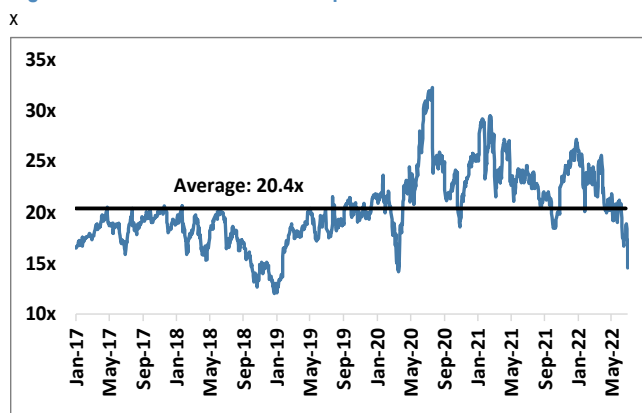
Source: Bloomberg Finance L.P.

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Teradyne Summary Table

$ in millions, except for per share data

	2020	1Q21	2Q21	3Q21	4Q21	2021	1Q22	2Q22E	3Q22E	4Q22E	2022E	1Q23E	2Q23E	3Q23E	4Q23E	2023E
Semiconductor Test	2,259	528	834	688	592	2,642	482	542	585	622	2,231	675	775	763	653	2,866
System Test	410	133	105	103	127	468	119	102	103	117	440	124	110	109	118	461
Wireless Test	173	41	55	69	52	217	52	58	68	70	248	53	58	69	71	251
Industrial Automation	280	80	92	91	113	376	103	124	132	147	506	132	161	172	191	656
Total Revenue	**3,121**	**782**	**1,086**	**951**	**885**	**3,703**	**755**	**826**	**888**	**956**	**3,425**	**983**	**1,105**	**1,113**	**1,033**	**4,233**
Y/Y % Chg.	*36.0%*	*11.0%*	*29.5%*	*16.0%*	*16.6%*	*18.6%*	*(3.4)%*	*(23.9)%*	*(6.6)%*	*8.0%*	*(7.5)%*	*30.1%*	*33.8%*	*25.3%*	*8.1%*	*23.6%*
Gross Margin	*57.2%*	*59.1%*	*59.6%*	*60.1%*	*59.6%*	*59.6%*	*60.2%*	*60.4%*	*60.3%*	*60.6%*	*60.4%*	*59.8%*	*59.1%*	*59.7%*	*61.5%*	*60.0%*
Operating Expense	839	230	250	242	253	975	248	264	280	296	1,088	290	301	309	318	1,218
as % of Sales	*26.9%*	*29.5%*	*23.0%*	*25.5%*	*28.6%*	*26.3%*	*32.9%*	*32.0%*	*31.5%*	*31.0%*	*31.8%*	*29.5%*	*27.2%*	*27.8%*	*30.8%*	*28.8%*
Operating Income	**947**	**231**	**397**	**329**	**274**	**1,231**	**207**	**234**	**256**	**283**	**980**	**297**	**353**	**355**	**317**	**1,322**
Operating Margin	*30.3%*	*29.6%*	*36.5%*	*34.6%*	*31.0%*	*33.3%*	*27.4%*	*28.4%*	*28.8%*	*29.6%*	*28.6%*	*30.3%*	*31.9%*	*31.9%*	*30.7%*	*31.2%*
Net Income	**800**	**196**	**338**	**279**	**238**	**1,051**	**169**	**193**	**211**	**234**	**807**	**244**	**291**	**292**	**261**	**1,089**
Diluted EPS	**$4.59**	**$1.11**	**$1.91**	**$1.59**	**$1.37**	**$5.96**	**$0.98**	**$1.13**	**$1.25**	**$1.40**	**$4.75**	**$1.47**	**$1.77**	**$1.79**	**$1.61**	**$6.65**
Diluted Shares (avg.)	175	177	177	175	175	176	173	171	169	167	170	166	164	163	162	164
Cash	1,436	1,309	1,237	1,313	1,366	1,366	1,077	1,054	1,050	1,051	1,051	1,056	1,096	1,213	1,357	1,357
Debt	410	368	357	145	108	108	96	96	96	96	96	96	96	96	96	96
Net Debt	(1,026)	(942)	(879)	(1,168)	(1,258)	(1,258)	(981)	(958)	(954)	(956)	(956)	(960)	(1,000)	(1,117)	(1,261)	(1,261)
Net Leverage (ttm)	(1.0x)	(0.9x)	(0.7x)	(0.9x)	(0.9x)	(0.9x)	(0.7x)	(0.8x)	(0.9x)	(0.9x)	(0.9x)	(0.8x)	(0.8x)	(0.8x)	(0.9x)	(0.9x)
Operating Cash Flow	869	38	206	523	331	1,098	7	233	255	263	758	217	258	334	358	1,168
Capital Expenditures	(185)	(39)	(35)	(29)	(29)	(132)	(44)	(37)	(40)	(43)	(164)	(44)	(50)	(50)	(46)	(190)
Free Cash Flow	684	(1)	172	493	302	966	(37)	196	215	220	594	173	209	284	312	977
Dividends	(66)	(17)	(17)	(16)	(16)	(66)	(18)	(19)	(19)	(18)	(74)	(18)	(18)	(18)	(18)	(72)
Share repurchases	(88)	(45)	(151)	(210)	(194)	(600)	(201)	(200)	(200)	(200)	(801)	(150)	(150)	(150)	(150)	(600)

Source: Company reports and J.P. Morgan estimates.

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Management

Mark Jagiela, Chief Executive Officer

Mark Jagiela has served as CEO since February 2014. Prior to his appointment to CEO, he served as the President of the Semiconductor Test Division in 2003-14, worldwide marketing manager of semiconductor test products from 2001 to 2003, and GM of Teradyne's Japan division over 1989-1999. He joined Teradyne in 1982 as a design engineer. He holds a BSEE from the University of Michigan.

Sanjay Mehta, Chief Financial Officer

Sanjay Mehta has served as CFO since April 2019 and oversees finance, IT, global infrastructure, and supply management. Prior to joining Teradyne in 2019, he served as Qualcomm's President of QCT China over 2016-18 and as CFO of QCT from 2010 to 2015. He is a Chartered Accountant and holds a Bachelor of Commerce from the University of Toronto.

Charles Gray, General Counsel and Secretary

Charles Gray joined Teradyne in 2009 in his current role as General Counsel and Secretary. Prior to his tenure at Teradyne, he served as General Counsel at Sonus Networks, Appian Communications, and ArrowPoint Communications. He is a graduate of Georgetown University and Boalt Hall School of Law at the University of California, Berkeley.

Walter Vahey, Business Development

Walter Vahey is the current head of Corporate Development at Teradyne; prior to his current role, he served as the President of the System Test Division, and as the GM of the Defense & Aerospace and Storage Test businesses. He has been at the firm since 1986 and held a variety of roles in engineering, sales, and marketing. He holds a BS in Electrical and Computer Engineering from Carnegie Mellon University.

Rick Burns, President of Semiconductor Test

Rick Burns joined Teradyne in 2007 and has served in a variety of roles, including VP of Semiconductor Test Engineering. He has over 30 years of engineering, engineering management, and business leadership. He holds a BS in Physics from the University of California, Los Angeles, and an MSEE from the California State University, Northridge.

John Wood, GM of System Test

John Wood joined Teradyne in 1977 and has held a variety of roles in process engineering, design engineering, and program management. Prior to his current role, he was GM of the Defense & Aerospace test business since 2012, and named VP in 2014. He holds an AS in Electrical Engineering Technology from Northeastern University.

Brad Robbins, President of LitePoint

Brad Robbins has worked at LitePoint since its acquisition in 2011, and became president of LitePoint in 2014. He has held various positions in division general management, marketing strategy, product development, and technology strategy at Teradyne. He holds a BSEE in Electrical Engineering from Tufts University.

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Greg Smith, President of Industrial Automation

Greg Smith oversees the Industrial Automation Group, which includes Universal Robots, MiR – Mobile Industrial Robots, and AutoGuide. Prior to leading the IA Group, Greg Smith was President of the Semiconductor Test segment. He began his career at Raytheon as a test engineer and held other roles in engineering and management prior to joining Teradyne in 2006. He holds a bachelor's degree in Electrical Engineering from the University of Pennsylvania.

Note: Mr. Smith was recently appointed President of Teradyne, effective July 1, 2022 (link). Mark Jagiela will continue on as Chief Executive Officer. The move underscores the increasing importance of Teradyne's non-test business and focus on scaling its collaborative robot and autonomous mobile robots offerings.

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05 July 2022

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Investment Thesis, Valuation and Risks

Teradyne, Inc. *(Neutral; Price Target: $120.00)*

Investment Thesis

We rate Teradyne shares Neutral, led by favorable market competition dynamics as one of two main players in Semiconductor Test and a high level of "stickiness" with major customers. Following a downcycle in 2022, Teradyne expects a revenue inflection starting in 2023 from TSMC's introduction of 3 nm (for which Apple is a primary customer), as well as from other technology transitions that drive greater complexity and need for testing. In addition, TER is diversifying into Industrial Automation, in which it has an early leading position, helping to offset cyclicality associated with the Test business. The above leads us to forecast a high-single-digit revenue and earnings growth CAGR through FY24, albeit with pronounced cyclicality. However, we are less confident about the long-term drivers justifying TER shares to trade at an average of 20x+ P/E (2022E), given the cyclicality in both revenue and earnings around technology transition timing, as well as a much lower trading multiple for closest competitor Advantest, trading at 14x (vs. TER at 20x).

Valuation

We introduce our Dec-22 price target of $120 based on applying an 18x P/E multiple to our 2023E EPS of $6.65. We believe the target multiple, which is still modestly above the peer group average, is justified on the balance of a robust revenue and earnings outlook relative to peers, while embedding risk of downcycles.

Table 10: P/E-Based Valuation

	NTM Qtrs 1-4	2023E
JPM Net Income	807	1089
JPM EPS	$4.75	$6.65
P/E Multiple	18.0x	
JPM P/E Multiple		18x
Implied Equity Value	15,057	19,596
Average Diluted Share Count	175	164
Implied Share Price	**$85.8**	**$120.0**
Current Value per Share	$85.80	$85.80
Upside vs. Current		40%
Memo:		
(-) Net Cash/(Debt)	1,168	1,261
Enterprise Value	13,889	18,335
JPM EBITDA	1,084	1,469
Implied EV/EBITDA	*12.8x*	*12.5x*

Source: Company reports and J.P. Morgan estimates.

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Risks to Rating and Price Target

Industry Upside Risks

Adoption of new technology architectures (e.g., GAA, chiplet designs) accelerates, requiring greater test times; new cellular and Wi-fi standards require a greater degree of testing; new use cases of cobots and/or autonomous mobile robots increase, or industrial automation tools are adopted more rapidly than expected.

Company-Specific Upside Risks

Teradyne gains market share from competitors, e.g., displacing Advantest in Compute; faster adoption of DDR5/PDDR5 than expected, driving growth in Memory Test; Teradyne is able to scale the Industrial Automation segment more rapidly than expected, accelerating diversification and moderating cyclicality of the total business.

Industry Downside Risks

Pace of node advancements (e.g., from 3 nm to 2 nm) slows materially, diminishing testing requirements; customers find test efficiencies moderating the demand for test equipment; migration to industrial automation slows due to macro pullback or other secular shifts.

Company-Specific Downside Risks

Apple does not adopt 3 nm for its next product cycle in 2023 or adopts it for only a minority of the product portfolio; Teradyne cedes share to competitors due to slowing innovation or poor execution; other industrial automation tools emerge as the preferred technology among customers.

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Teradyne: Summary of Financials

Income Statement - Annual	FY20A	FY21A	FY22E	FY23E	FY24E
Revenue	3,121	3,703	3,425	4,233	4,587
COGS	(1,335)	(1,496)	(1,356)	(1,693)	(1,847)
Gross profit	-	-	-	-	-
SG&A	(464)	(548)	(593)	(666)	(692)
Adj. EBITDA	**1,074**	**1,357**	**1,096**	**1,469**	**1,606**
D&A	(127)	(125)	(116)	(146)	(159)
Adj. EBIT	**947**	**1,231**	**980**	**1,322**	**1,448**
Net Interest					-
Adj. PBT	**944**	**1,229**	**960**	**1,302**	**1,428**
Tax	(144)	(178)	(152)	(214)	(228)
Minority Interest	-	-	-	-	-
Adj. Net Income	**800**	**1,051**	**807**	**1,089**	**1,199**
Reported EPS	4.59	5.96	4.75	6.65	7.55
Adj. EPS	**4.59**	**5.96**	**4.75**	**6.65**	**7.55**
DPS	0.40	0.40	0.44	0.44	0.48
Payout ratio	8.7%	6.7%	9.3%	6.6%	6.4%
Shares outstanding	175	176	170	164	159

Income Statement - Quarterly	1Q22A	2Q22E	3Q22E	4Q22E
Revenue	755A	826	888	956
COGS	(300)A	(327)	(352)	(376)
Gross profit	-	-	-	-
SG&A	(140)A	(145)	(151)	(158)
Adj. EBITDA	**234A**	**259**	**286**	**316**
D&A	(28)A	(25)	(30)	(33)
Adj. EBIT	**207A**	**234**	**256**	**283**
Net Interest	-	-	-	-
Adj. PBT	**201A**	**229**	**251**	**278**
Tax	(32)A	(37)	(40)	(44)
Minority Interest	-	-	-	-
Adj. Net Income	**169A**	**193**	**211**	**234**
Reported EPS	0.98A	1.13	1.25	1.40
Adj. EPS	**0.98A**	**1.13**	**1.25**	**1.40**
DPS	0.11A	0.11	0.11	0.11
Payout ratio	11.3%A	9.8%	8.8%	7.9%
Shares outstanding	173A	171	169	167

Balance Sheet & CashFlow Statement	FY20A	FY21A	FY22E	FY23E	FY24E
Cash and cash equivalents	914	1,122	769	1,075	1,491
Accounts receivable	498	551	563	746	812
Inventories	222	243	230	212	242
Other current assets	782	660	774	774	774
Current assets	**2,415**	**2,576**	**2,336**	**2,806**	**3,318**
PP&E	395	387	431	475	523
LT investments	118	134	126	126	126
Other non current assets	724	712	709	709	709
Total assets	**3,652**	**3,809**	**3,602**	**4,116**	**4,677**
Short term borrowings	33	19	20	20	20
Payables	134	153	167	265	302
Other short term liabilities	534	633	535	535	535
Current liabilities	**701**	**805**	**723**	**821**	**858**
Long-term debt	377	89	75	75	75
Other long term liabilities	364	351	347	347	347
Total liabilities	**1,442**	**1,245**	**1,145**	**1,243**	**1,280**
Shareholders' equity	2,211	2,564	2,457	2,873	3,396
Minority interests	-	-	-	-	-
Total liabilities & equity	**3,652**	**3,809**	**3,602**	**4,116**	**4,677**
Net debt/(cash)	(504)	(1,014)	(674)	(979)	(1,395)
Cash flow from operating activities	**869**	**1,098**	**758**	**1,168**	**1,299**
o/w Depreciation & amortization	127	125	116	146	159
o/w Changes in working capital	(69)	(107)	(186)	(67)	(59)
Cash flow from investing activities	**(570)**	**120**	**(203)**	**(190)**	**(206)**
o/w Capital expenditure	(185)	(132)	(164)	(190)	(206)
as % of sales	*5.9%*	*3.6%*	*4.8%*	*4.5%*	*4.5%*
Cash flow from financing activities	**(158)**	**(1,009)**	**(910)**	**(672)**	**(676)**
o/w Dividends paid	(66)	(66)	(74)	(72)	(76)
o/w Net debt issued/(repaid)	-	-	-	-	-
o/w Share Repurchases	(88)	(600)	(801)	(600)	(600)
Net change in cash	**140**	**208**	**(353)**	**305**	**416**
Adj. Free cash flow to firm	**684**	**966**	**594**	**977**	**1,092**

Ratio Analysis	FY20A	FY21A	FY22E	FY23E	FY24E
Gross margin	-	-	-	-	-
EBITDA margin	34.4%	36.6%	32.0%	34.7%	35.0%
EBIT margin	30.3%	33.3%	28.6%	31.2%	31.6%
Net profit margin	25.6%	28.4%	23.6%	25.7%	26.1%
ROE	43.4%	44.0%	32.2%	40.8%	38.3%
ROA	24.9%	28.2%	21.8%	28.2%	27.3%
ROCE	35.7%	39.8%	31.6%	40.0%	37.6%
SG&A/Sales	14.9%	14.8%	17.3%	15.7%	15.1%
Net debt/equity	NM	NM	NM	NM	NM
Net debt/EBITDA	NM	NM	NM	NM	NM
P/E (x)	18.7	14.4	18.1	12.9	11.4
P/BV (x)	-	-	-	-	-
EV/EBITDA (x)	15.0	11.8	14.7	10.9	10.0
Dividend Yield	0.5%	0.5%	0.5%	0.5%	0.6%
Sales/Assets (x)	1.0	1.0	0.9	1.1	1.0
Interest cover (x)	-	-	-	-	-
Operating leverage	173.8%	161.2%	271.8%	147.9%	113.6%
Revenue y/y Growth	36.0%	18.6%	(7.5%)	23.6%	8.3%
EBITDA y/y Growth	52.7%	26.4%	(19.2%)	34.0%	9.4%
Tax rate	15.3%	14.5%	15.9%	16.4%	16.0%
Adj. Net Income y/y Growth	62.0%	31.3%	(23.2%)	34.9%	10.2%
EPS y/y Growth	61.6%	30.0%	(20.4%)	40.1%	13.6%
DPS y/y Growth	11.1%	0.0%	10.0%	0.0%	9.1%

Source: Company reports and J.P. Morgan estimates.

Note: $ in millions (except per-share data).Fiscal year ends Dec. o/w - out of which

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North America Equity Research
05 July 2022

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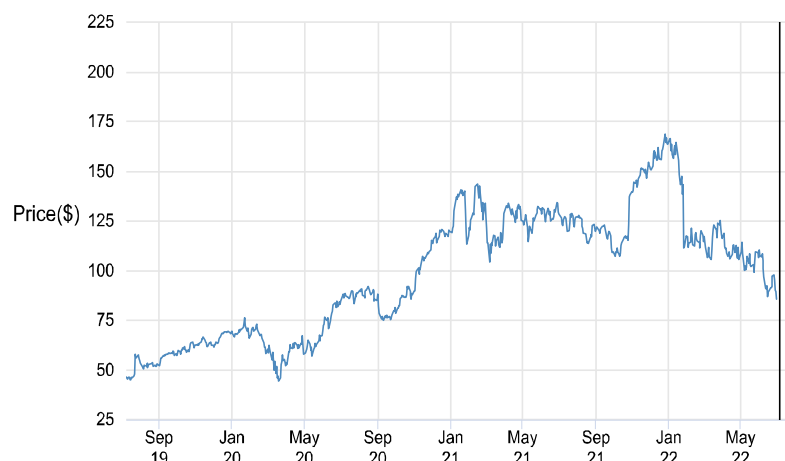
Source: Bloomberg Finance L.P. and J.P. Morgan; price data adjusted for stock splits and dividends.
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North America Equity Research
05 July 2022

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05 July 2022

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