

J.P. Morgan Semiconductor and Semiconductor Capital Equipment

2020 Virtual Summer Lunch Series

Harlan Sur ^{AC}

415-315-6700

harlan.sur@jpmorgan.com

J.P. Morgan Securities LLC

Bill Peterson ^{AC}

415-315-6766

bill.peterson@jpmorgan.com

J.P. Morgan Securities LLC

Peter Peng

415-315-8327

peter.k.peng@jpmorgan.com

J.P. Morgan Securities LLC

Alex Kim

415-315-8828

alexander.kim@jpmorgan.com

J.P. Morgan Securities LLC

See the end pages of this presentation for analyst certification and important disclosures, including non-US analyst disclosures.

J.P. Morgan does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision.

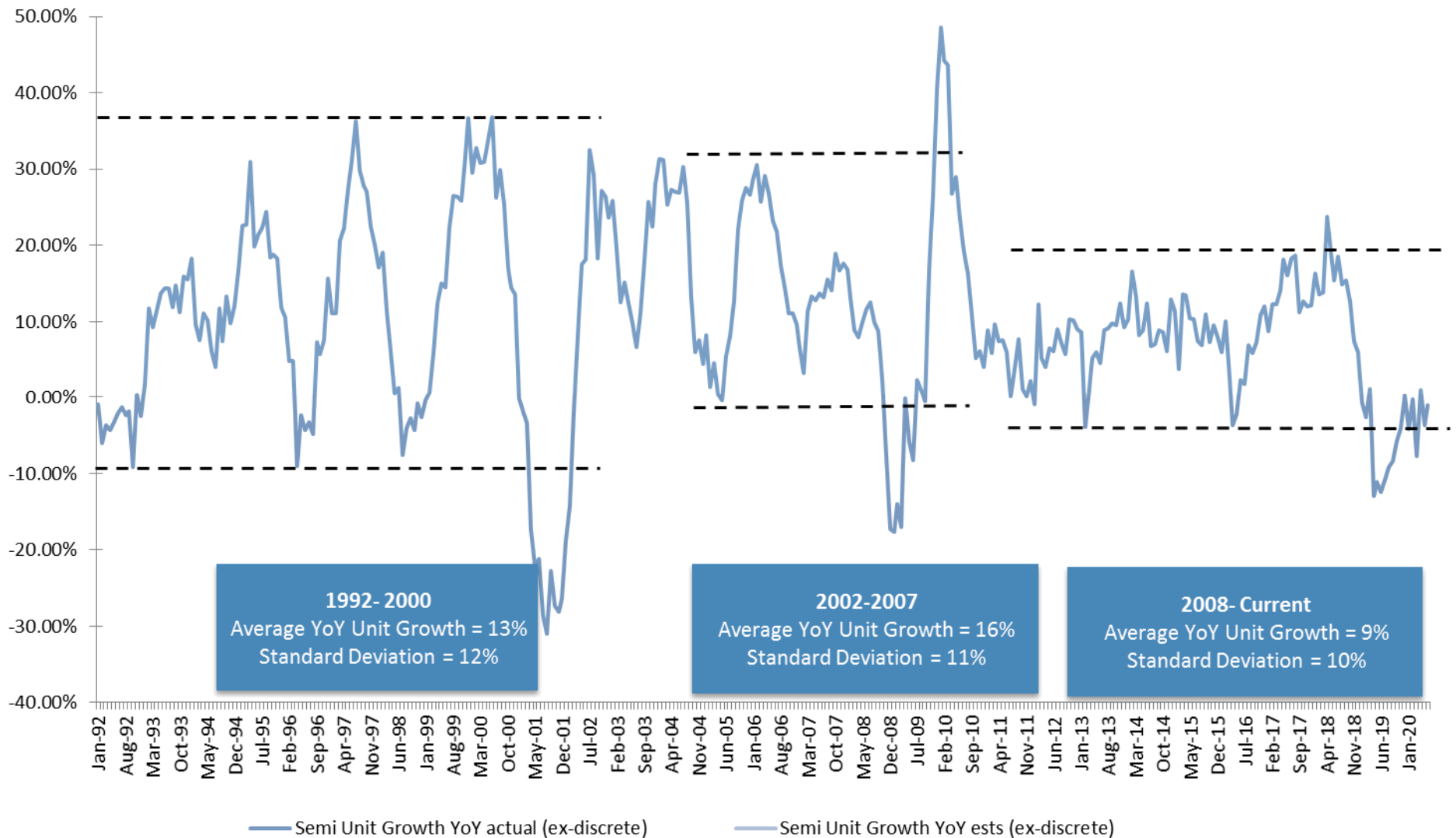
Semi/Semicaps – Remain Positive on the Group...Continue to Accumulate...Our Top Picks Are Broadcom (AVGO) and KLA (KLAC)

- **We believe the semiconductor industry has entered a more stable and less cyclical growth phase characterized by low- to mid-single-digit annual revenue growth and high-single-digit unit growth**
 - With the industry generally driving high-single-digit Y/Y unit growth, the entire value chain is able to better predict silicon consumption requirements, better respond to perturbations in supply/demand, and more efficiently plan manufacturing output
 - As a result, volatility in semiconductor supply/demand and semiconductor equipment spending has muted significantly
 - Compare this to 10 years ago, when unit growth rates were +15% Y/Y – small perturbations in supply/demand would drive significant swings in inventory, shipments, capacity planning, and equipment spending
 - **Bottom line: the current environment is likely more stable and less cyclical for semiconductor and semiconductor capital equipment suppliers. In a maturing industry, we believe the market will focus on market leadership/scale, operating margin and free cash flow margin expansion, and increasing payout ratios**
- **After 2019, when semi industry revenue (ex-memory) declined ~6% (ex-memory) and wafer fab equipment (WFE) spending was impacted by memory spending (down 30%+), as suppliers remain disciplined & focused on profitability, we estimate 2020 semi industry growth up low-single-digits % and semiconductor equipment spending up ~10% with growth in 2H20 vs. 1H20. 2021 Semi industry outlook of +8-10% and semicap spending of up 5-10%.**
- **In 2H20, similar to 2H19, we anticipate stocks continuing to positively discount better global macroeconomic demand trends 9 months forward as long as there's no COVID-19 resurgence during the upcoming winter months. We anticipate continued volatility in stocks on US/China trade conflict and on COVID-19. However, assuming no further deterioration of US/China trade conflict/COVID-19, we see stocks continuing to outperform for the remainder of 2020 as the market discounts a better 2021 macro environment and positive EPS revisions.**
- **Channel inventories remain normal/lean and end customers are carrying slightly higher levels of inventories and aren't likely to burn them off in 2H20 on fears of a COVID-19 resurgence/supply-chain disruptions:** Supply-side indicators such as distribution inventory and lead times remain disciplined, and our companies have proactively reduced shipments to keep channel inventories lean.
- **Record consolidation (M&A) wave should continue in the medium term:** Focus on scale, diversification, and margin and FCF expansion
- **Semis large-cap top pick: AVGO; we also favor MRVL, TXN, INTC, NVDA, MCHP, MU & QRVO – semis small-cap top pick: IPHI. UW XLNX**
 - Given continued volatility and potential trade concerns – we focus on market leadership, strong US-based exposure to cloud/5G infrastructure spending trends, strong product cycles, diversification, and margin/free cash flow expansion with increasing payout ratios.
- **Memory capex discipline should drive improved profitability in 2020. Semi capital equipment fundamentals to follow: top pick KLAC (OW)**

KLA's top-line is outperforming relative to industry peers on strong product cycles and robust Foundry/Logic spending. KLAC dominates the semiconductor process control equipment market with ~5x more market share than the #2 competitor. We are also OW LRCX & AMAT.

Semis in More Stable Growth Phase – Focus on Market Leadership, Strong Product Cycles, Margin/Free Cash Flow Expansion, and Capital Allocation

Semi Unit Growth YoY (ex-discrete)



Source: WSTS, J.P. Morgan estimates.

Earnings Revisions Turned Positive in the Recent 2Q Earnings Season and Semis/Semicap 2020 and 2021 Full-Year Industry Outlook Revisions Also Turned Positive

- **The 2Q20 earnings season reflected headwinds companies faced from COVID-19, but we believe 2Q20 marked the trough for most companies and recovery is expected for 2H20 vs. 1H20. In line with this view, we previewed EPS revisions were going to turn positive after a 15-30% cut in EPS estimates post the last 1Q20 earnings season**

- **Post the recent 2Q20 earnings season, semiconductor companies' full-year EPS estimates were revised higher by 12-25% AND the number of companies that delivered in-line/better out-quarter guidance rose to 90% versus 50% in the prior quarter...**
 - Semicap full-year EPS estimates were revised higher by 10-20% during the recent 2Q20 earnings season, and we anticipate further momentum on revisions as the 2021 WFE outlook for growth starts to solidify

- **We anticipate the market continuing to discount an improving economic outlook into 2021 (semis tend to discount 9 months forward) and continued positive earnings revisions into 2021 driven by the following:**
 - **GDP growth of 5.1% in CY21 versus -4.2% in CY20**
 - **Semi industry growth of 8-10% in CY21**
 - **Cloud / hyperscale capex spending growth of 23% in CY21**
 - **5G smartphone unit shipment growth of 130% in CY21**
 - **5G basestation deployment growth of 35% in CY21**
 - **Global light vehicle production growth of 12-13% in CY21**
 - **Petabyte growth in Capacity HDD of 35-40% and Client/Enterprise SSD shipments growth of 10-15%**

Broadcom (AVGO): Driving Strong Cloud Networking Upgrade Starting This Year, Strong Custom ASIC (Custom Chip) Pipeline

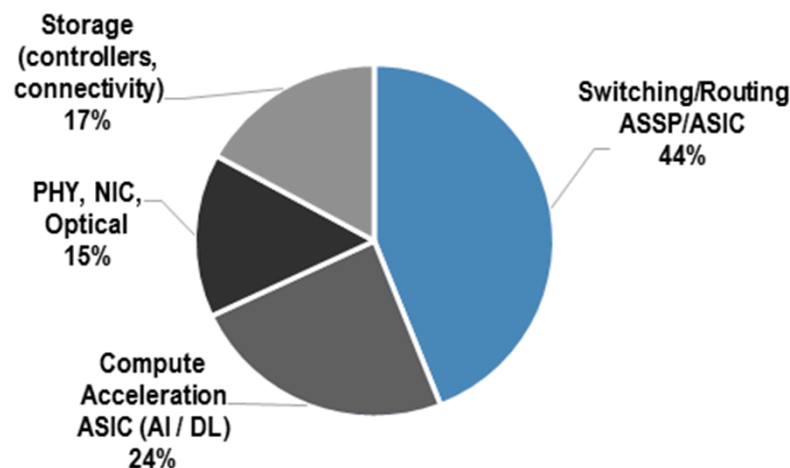
- **Still viewed as an Apple iPhone Supplier (non-core business)....market not appreciating the diversification of the business....~25% of total revenues are now exposed to cloud datacenter**
- **Category Killer in Cloud Datacenter Networking....>85% share of merchant and ASIC switching silicon opportunity ~\$3B per year growing 10-15% Y/Y**
 - Tomahawk 3 (50G PAM4 per port) production ramp started 2H18 – significant upgrade cycle in 2020
 - Tomahawk 4 (50G PAM4 per port) sampling now
 - Not only leader in switch/routing – but also NIC, PHY, optical silicon as well to support the switch silicon
- **Category Killer in Artificial Intelligence Custom Processor Chips** to customers like Google (TPU1/2/3/4 and TPU5 beg. in 2021), Fujitsu, Intel, and several others...>\$1B business over next 12 months (from zero base in 2016)
- **Strong cloud infrastructure spending not only benefits Broadcom's leadership in switching/routing, but also its leadership in enterprise/cloud storage silicon – Enterprise SSD Controllers, HDD capacity cloud drive controllers, Storage HBA, Storage Systems connectivity**
- **Dividend at \$13 (from \$10.60 prior, or +23% Y/Y) and given continued strong FCF of the company and healthy fundamentals, we believe it opens up the possibility of a potential dividend increase in December**

Cloud Data Center Network/Storage Silicon SAM Opportunity and Growth

Segments	\$ SAM 2024e	SAM CAGR 2020e- 2024e
Data Center Networking Compute Acceleration	~ \$8.5B	13-15%
Data Center Storage	~ \$2.2B	5%
Combined	~ \$11B	~ 10-15%

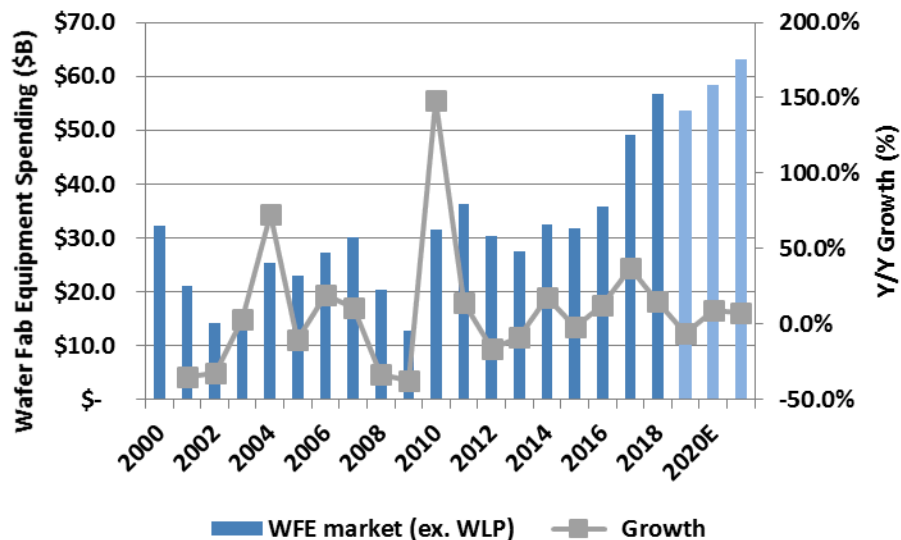
Source: J.P. Morgan estimates.

Cloud Datacenter Networking/Compute Acceleration ASIC/Storage Revenue Mix (25% of Total Revenues)



Source: J.P. Morgan estimates.

WFE Forecast and Key Programs for Semiconductor Manufacturers in 2020/2021



Source: Gartner and J.P. Morgan estimates.

* Data excludes wafer level packaging from 2013 (~\$2 billion per year)

Based on higher than expected Foundry/Logic spending, we now expect WFE spending to increase by ~10% in 2020

We expect Memory to recover modestly in 2020 on improving S/D fundamentals with Foundry/Logic showing further strength

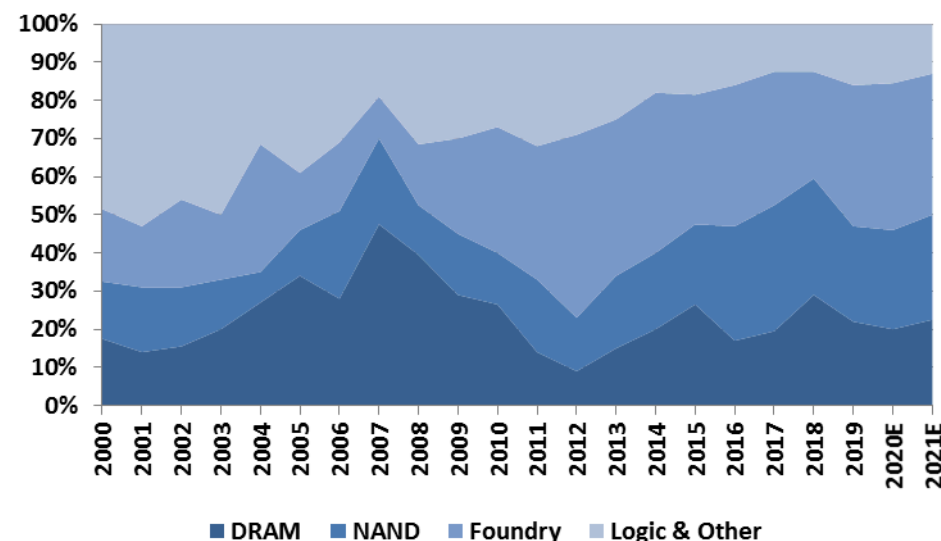
We expect 5-10% WFE growth in 2021 as Memory continues recovering with Foundry spending remaining strong

Key drivers:

- Memory WFE in 2020 held back on supply discipline, but we expect DRAM and NAND spending to accelerate in 2021
- Continued growth in Foundry/Logic in 2020 with spending to remain strong in 2021.
 - Broad-based across leading and lagging edge technologies
- Further growth in China spending in 2020 as local manufacturers come up the learning curve

Manufacturer	Segment	Technology
China	Foundry	28nm and above (Various)
China	Memory (DRAM)	2X/1Xnm DRAM (CXMT)
China	Memory (NAND)	64+ layer 3D NAND (YMTC, Wuhan)
Intel	Logic	10nm/7nm FinFET (Israel, Oregon)
Intel	Memory (NAND)	3D NAND (Dalian, China)
Micron	Memory (NAND)	RG 3D NAND (Singapore)
Micron	Memory (DRAM)	1Z/1α nm DRAM (Taiwan and Hiroshima Japan)
Samsung	Foundry/Logic	3nm & 5nm FF(S-3, Hwaseong, South Korea)
Samsung	Memory (NAND)	100+L 3D NAND (PTK, Korea & Xian, China)
Samsung	Memory (DRAM)	1Z/1α nm DRAM (PTK, South Korea)
SK hynix	Memory (NAND)	100+ L 3D NAND (Cheongju, South Korea)
SK hynix	Memory (DRAM)	1Z/1α nm DRAM (Incheon, Korea; Wuxi, China)
SMIC	Foundry	14nm (and above) production (China - Various)
TSMC	Foundry	3nm & 5nm FF (Taiwan)
WDC/Partner	Memory (NAND)	100+L 3D NAND (Yokkaichi and Kitakami Japan)

Source: Industry data and J.P. Morgan estimates.



6 Source: Industry data and J.P. Morgan estimates.

J.P.Morgan

Top Semicap Pick KLAC Dominates Process Control

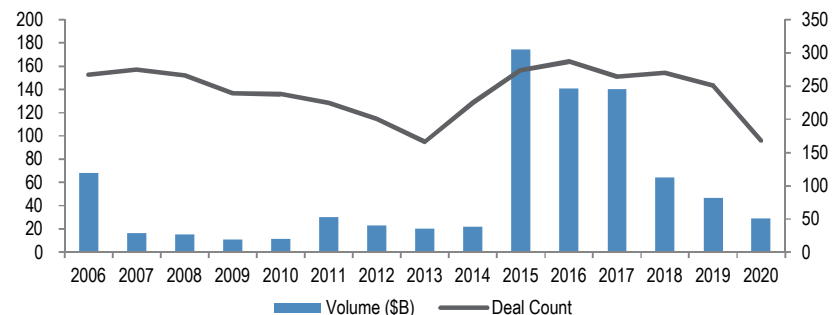
- **KLAC dominates the process control market with nearly 5x more market share than its nearest competitor**
- **Best-in-class margin profile ~60%+ GMs, 35%+ OPMs, 28-30% FCF margins...\$700M of R&D spending power dedicated to process control**
 - KLA's R&D spending is roughly equal to the revenues of its #2 competitor and 1.2-6x larger than the revenues of its next 8 competitors
- **Grew its process control systems business 2.5% last year when total WFE was down 6% and gained 270 basis points of market share in process control**
- **6% growth and 420 bps in share gain in pattern wafer inspection driven by Gen 5 optical and new e-beam wafer inspection platforms**
- **37% growth and 500 basis point share in mask (reticle) inspection**
- **700 bps share gain in overlay metrology and 100 bps share gain in thin film metrology**
- **Scale advantages and portfolio strategy that will keep KLA #1 in process control – using its dominance in pattern wafer inspection and mask (reticle) inspection as examples (these two businesses combined + services accounted for 40% of total CY19 sales)**
- **KLAC remains our top pick in semiconductor capital equipment**

Industry Consolidation Should Help Support Valuations...Expect More M&A Despite COVID-19

Announcement	Buyer	Target	Deal Value (\$M)	Status
7/13/2020	Analog Devices	Maxim Integrated	21,300	Pending
7/7/2020	Synaptics Inc.	Broadcom's Wireless IoT Connectivity Business	250	Pending
4/6/2020	MaxLinear	Intel's Connected Home Business	150	Completed
12/16/2019	Intel	Habana Labs	2,000	Completed
8/8/2019	Broadcom	Symantec's Enterprise Security Business	10,700	Completed
7/9/2019	Cisco Systems	Acacia Communications Inc.	2,600	Pending
7/1/2019	Applied Materials	Kokusai Electric	2,200	Pending
6/24/2019	Nanometrics Inc	Rudolph Technologies	N/A	Completed
6/10/2019	Intel	Barefoot Networks	N/A	Completed
6/3/2019	Infineon Technologies	Cypress	10,000	Completed
5/29/2019	NXP Semiconductors	Marvell's Connectivity Business	1,760	Completed
5/20/2019	Marvell Technology Group Ltd	Avera Semiconductor LLC	650	Completed
5/6/2019	Marvell Technology Group Ltd	Aquantia Corp	452	Completed
4/10/2019	Qorvo Inc.	Active-Semi International	325	Completed
3/27/2019	ON Semiconductor Corp.	Quantenna Communications Inc.	1,070	Completed
3/15/2019	Ideal Industries	Cree Huizhou Solid State Lighting Co Ltd	310	Completed
3/11/2019	Nvidia Corp.	Mellanox Ltd.	6,900	Completed
12/18/2018	Cisco Systems	Luxtera	660	Completed
10/30/2018	MKS Instruments	Electro Scientific Industries	1,000	Completed
9/11/2018	Renesas	Integrated Device Technology	6,700	Completed
7/11/2018	Broadcom Inc.	CA Technologies	18,900	Completed
5/8/2018	Cohu	Xcerra Corp	796	Completed
3/19/2018	KLA-Tencor Corp.	Orbotech Ltd.	3,200	Completed
3/6/2018	Cree	Infineon RF Power	428	Completed
3/1/2018	Microchip Technology	Microsemi Corp	10,150	Completed
11/20/2017	Marvell Technology Group Ltd	Cavium Inc	6,018	Completed
10/5/2017	Dialog Semiconductor	Silego technology	276	Completed
9/22/2017	Canyon Bridge Capital	Imagination Technologies	743	Completed
6/12/2017	Synaptics Inc	Conexant Systems	341	Completed
3/29/2017	MaxLinear Inc.	Exar Corp	446	Completed
3/13/2017	Intel	Mobileye	15,300	Completed
2/13/2017	IDT	Gigpeak	250	Completed
2/2/2017	Veeco	Ultratech	815	Completed
12/21/2016	TDK	Invensense	1,300	Completed
11/21/2016	MACOM	Applied Micro	770	Completed
11/2/2016	Broadcom	Brocade	5,900	Completed
10/31/2016	Inphi	ClariPhy	275	Completed
9/23/2016	Shanghai Capital	Analogix Semiconductor	500	Completed
9/13/2016	Renesas	Intersil	3,200	Completed
8/25/2016	Littelfuse Inc.	ON Semi's Ignition IGBT business	100	Completed
7/26/2016	Analog Devices	Linear Technology	14,800	Completed
7/17/2016	Softbank	ARM Holdings	32,000	Completed
6/15/2016	Cavium	QLogic	1,360	Completed
6/14/2016	JAC Capital	NXP's Standard Products Business	2,750	Completed
5/18/2016	ARM Holdings PLC	Apical Ltd	350	Completed
5/13/2016	NavInfo Co. Ltd	Autochips Heifei Inc.	598	Completed
4/28/2016	Cypress	Broadcom's IoT	550	Completed
3/3/2016	Cisco Systems	Leaba Semiconductor Ltd	320	Completed
2/23/2016	MKS Instruments	Newport Corporation	980	Completed
2/4/2016	FormFactor Inc	Cascade Microtech	296	Completed
1/13/2016	Microchip	Atmel	3,420	Completed
12/14/2015	Micron Technology	Inolera Memories	3,200	Completed
11/18/2015	ON Semiconductor	Fairchild Semiconductor	2,400	Completed
10/26/2015	Integrated Device Technology	ZMDI	310	Completed
10/21/2015	Western Digital	Sandisk	19,000	Completed
10/20/2015	MicroSemi	PMC-Sierra	2,400	Completed
9/30/2015	Mellanox	Ezchip	811	Completed
9/7/2015	Mediatek	Richtek	879	Completed
6/1/2015	Intel	Altera	16,700	Completed

- **Semiconductors consolidating to focus on gaining:**
 - Build scale and drive profitability improvements
 - End-market diversification
- **Consolidation should drive more stable revenue growth and margins**
 - Less competition leads to less pricing pressure
 - More market leadership and diversity
- **2015-2018 have seen \$100B+ per year in M&A deal activity versus the \$20-30B run-rate prior to this time period . . . even in 2020 deal activity still ~\$30B**
- **M&A characterized by “big getting bigger” . . . we expect to start seeing a lot more M&A activity with the smaller/medium-sized companies as there is pressure to drive scale to compete with much bigger competitors**

Annual M&A Volume (\$B) and Deal Count Picked up Significantly in 2015 . . . and Should Continue



Custom Chip (ASIC) Market Experiencing a Resurgence in Activity as Large OEMS/Cloud/Hyperscalers Look to Differentiate at the Silicon Level

- Demand is rising for custom ASICs because many of the large OEMs/CSPs/Hyperscalers are looking for more differentiation, better performance, lower power consumption, and overall lower cost of ownership versus off-the-shelf chip solutions (or ASSPs)
- At the same time, these same customers do not have the capabilities to do large complex system-on-a-chip (SOC) designs, nor do they have the broad IP portfolio of on-chip design blocks, like high-speed SERDES capabilities or high-speed memory interface technology. They need to engage with semiconductor companies (ASIC companies) that have the IP and chip design expertise (Broadcom, Marvell, Intel, MediaTek, Inphi as examples)
- The digital custom ASIC chip market is a ~\$10-12B per year market opportunity:
 - Cloud/Hyperscale ASICS (AI processors, SmartNICs, Security/Video processors, Networking/Storage acceleration)
 - Telco/service provider equipment OEMs (5G basestation modem, 5G digital front end, 5G MIMO/Beamforming DSPs, Coherent DSPs for long haul/metro)

Snapshot of Broadcom's Custom ASIC Programs

Broadcom ASIC Customers	Programs	Technology	Status
Google	TPU1	28nm Technology	Deployed
Google	TPU2	16nm Technology	Deployed
Google	TPU3	16nm Technology	Deployed
Google	TPU4	7nm Technology	Begun production in 2Q20
Google	TPU5	5nm Technology	Target tape out 2021
Google	Switching	7nm Technology	Target tape out 2021
Facebook	ASIC	16nm Technology	Security Accel, 2020
Facebook	ASIC	7nm Technology	Video Accel, 2020
Facebook	ASIC	7nm Technology	Security Accel, 2021
Microsoft	ASIC	7nm Technology	Security Accel, 2020
Microsoft	ASIC	7nm Technology	SmartNIC
Tier-1 US Service provider	ASIC	16nm Technology	SmartNIC
Alibaba	ASIC	16nm Technology	SmartNIC
Fujitsu	ASIC	7nm Technology	AI acceleration
Cambricon	ASIC	7nm Technology	AI acceleration
SambaNova	ASIC	7nm Technology	AI acceleration
Nokia/Ericsson/ZTE	ASIC	16nm/7nm Technology	5G Basestation /Radio Head
Apple	ASIC	16nm	Next Gen iPhone Touch IC

Snapshot of 5G ASIC Programs

	Broadcom	Intel	Marvell
Huawei			
ZTE	Digital ASIC	Digital ASIC/CP	DFE ASIC *
Nokia	Digital ASIC/RRH	Digital ASIC/CP	Digital ASIC/CP/FH
Ericsson	Digital ASIC	Digital ASIC/CP	DFE ASIC *
Samsung			Digital ASIC/CP/RRH

Digital ASIC - BTS Modem or SP Routing

CP - Control/Dataplane Processor

DFE ASIC - Digital Front End ASIC (Radio Head)

RRH DSP/ASIC - Beam Forming DSP Processor

FH (Front haul high speed connectivity)

* Avera Acquisition

Source: JP Morgan Research

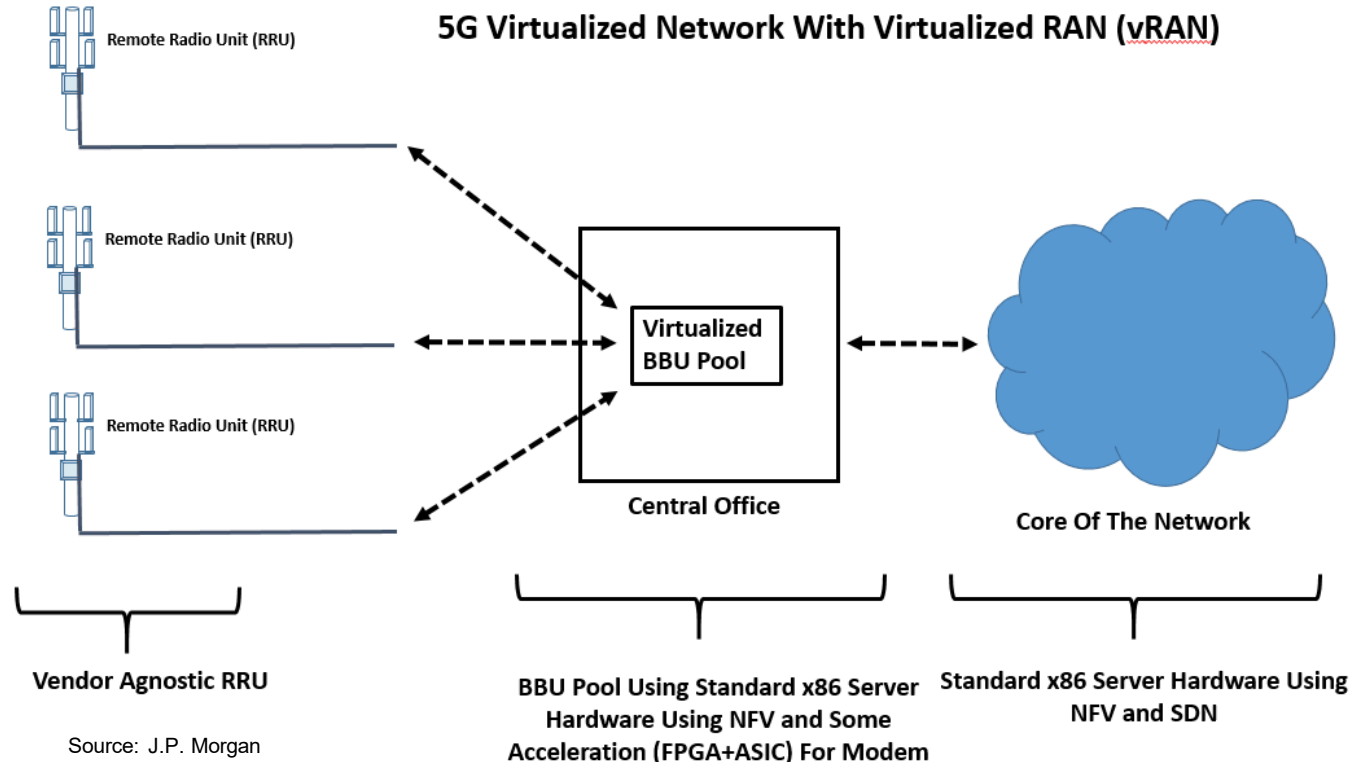
J.P.Morgan

Source: JP Morgan Research

5G Networks – Moving to Virtualized from Core to the Radio Access Network

■ Cellular Networks Moving to Virtualized – Starting With the Core and Moving to the Radio Access Network (vRAN)

- Core Network: Virtualized using x86 (primarily Intel) with Network Functions Virtualization (NFV) and Software Defined Networks (SDN)
- Radio Access Network (RAN) in the process of being virtualized with baseband units (BBU) disaggregated from remote radio units (RRU)
- Semiconductor Winners in a vRAN environment:
 - x86 general compute (Intel, AMD)
 - Accelerated / Compute Offload – FPGA (Xilinx, Intel) with some of the functions addressed by ASICs (Marvell, Broadcom, Intel)
 - vRAN Neutral to Positive for Analog and RF assuming more competition in remote radio units (RRU)



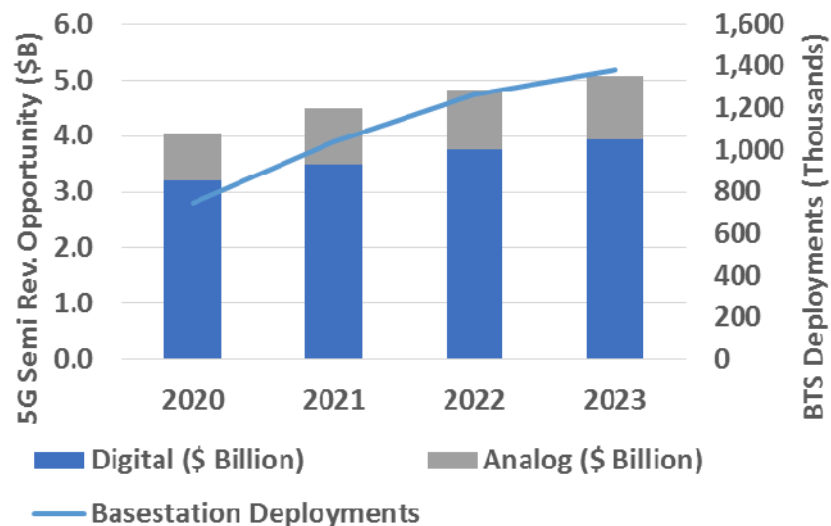
Source: J.P. Morgan

5G Wireless Infrastructure: Massive MIMO / Beamforming Represents Significant Growth Opportunity for Semiconductor Coverage Universe

5G Basestation / Massive MIMO Deployments Semiconductor Revenue Growth Opportunity of 7-9% CAGR (2020-2023E)

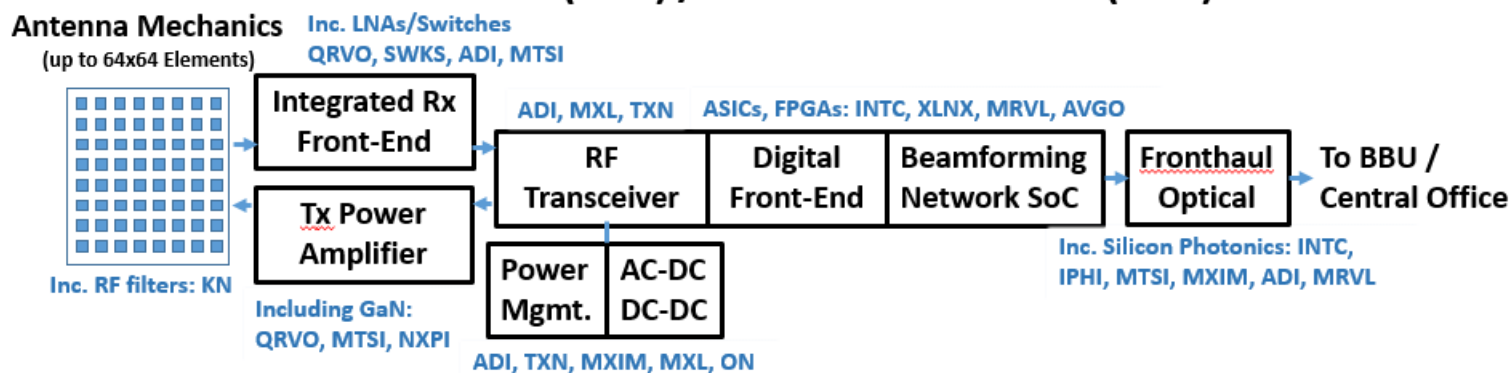
- 5G Basestation deployments reaching ~1.4M by 2023 (up from ~750K in 2020)
- Annual Revenue Opportunities – 5G Basestations:
 - Digital: growing from ~\$3B in 2020 to ~\$4B in 2023
 - Analog: ~\$0.8B in 2020 to \$1.1-1.2B in 2023
- Massive MIMO/Beamforming are key enablers of 5G sub-6 GHz and mmWave to increase network capacity, data rates with better energy efficiency and TCO
- Significant content opportunities from Antenna to Front-haul
- GaN opportunity scales with number of antenna elements
 - From ~\$350M in 2020E to ~\$550M in 2023E (15%-20% CAGR)

5G Basestation Semiconductor Revenue Opportunity and 5G Basestation Deployments – (2020-2023E)



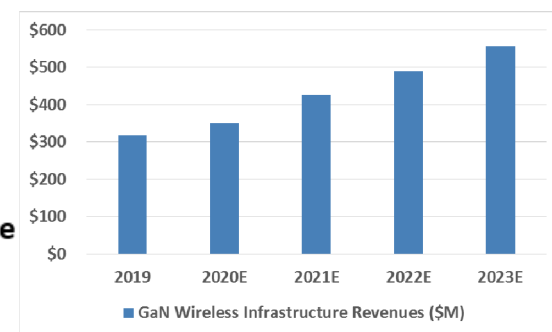
Source: IDC and J.P. Morgan estimates.

Types of Semiconductors Used in 5G Remote Radio Units (RRU) / Active Antenna Units (AAU)



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

GaN Wireless Infrastructure Revenue Opportunity (2019-2023E)



Source: Yole Développement and J.P. Morgan estimates.

Disclosures

Companies Discussed in This Report (all prices in this report as of market close on 19 August 2020)

Applied Materials(AMAT/\$65.87/OW), Broadcom Inc(AVGO/\$329.21/OW), Inphi(IPHI/\$113.13/OW), Intel(INTC/\$48.33/OW), KLA Corporation(KLAC/\$210.54/OW), Lam Research(LRCX/\$372.19/OW), Marvell Technology Group(MRVL/\$33.11/OW), Microchip Technology(MCHP/\$108.12/OW), Micron Technology(MU/\$44.05/OW), NVIDIA Corporation(NVDA/\$485.54/OW), Qorvo(QRVO/\$132.46/OW), Texas Instruments(TXN/\$138.48/OW), Xilinx(XLNX/\$102.39/UW)

Disclosures

Analyst Certification: The research analyst(s) denoted by an “AC” on the cover of this report certifies (or, where multiple research analysts are primarily responsible for this report, the research analyst denoted by an “AC” on the cover or within the document individually certifies, with respect to each security or issuer that the research analyst covers in this research) that: (1) all of the views expressed in this report accurately reflect the research analyst’s personal views about any and all of the subject securities or issuers; and (2) no part of any of the research analyst’s compensation was, is, or will be directly or indirectly related to the specific recommendations or views expressed by the research analyst(s) in this report. For all Korea-based research analysts listed on the front cover, if applicable, they also certify, as per KOFIA requirements, that their analysis was made in good faith and that the views reflect their own opinion, without undue influence or intervention.

All authors named within this report are research analysts unless otherwise specified. In Europe, Sector Specialists may be shown on this report as contacts but are not authors of the report or part of the Research Department.

Important Disclosures

Company-Specific Disclosures: Important disclosures, including price charts and credit opinion history tables, are available for compendium reports and all J.P. Morgan–covered companies by visiting <https://www.jpmm.com/research/disclosures>, calling 1-800-477-0406, or e-mailing research.disclosure.inquiries@jpmorgan.com with your request. J.P. Morgan’s Strategy, Technical, and Quantitative Research teams may screen companies not covered by J.P. Morgan. For important disclosures for these companies, please call 1-800-477-0406 or e-mail research.disclosure.inquiries@jpmorgan.com.

Explanation of Equity Research Ratings, Designations and Analyst(s) Coverage Universe:

J.P. Morgan uses the following rating system: Overweight [Over the next six to twelve months, we expect this stock will outperform the average total return of the stocks in the analyst’s (or the analyst’s team’s) coverage universe.] Neutral [Over the next six to twelve months, we expect this stock will perform in line with the average total return of the stocks in the analyst’s (or the analyst’s team’s) coverage universe.] Underweight [Over the next six to twelve months, we expect this stock will underperform the average total return of the stocks in the analyst’s (or the analyst’s team’s) coverage universe.] Not Rated (NR): J.P. Morgan has removed the rating and, if applicable, the price target, for this stock because of either a lack of a sufficient fundamental basis or for legal, regulatory or policy reasons. The previous rating and, if applicable, the price target, no longer should be relied upon. An NR designation is not a recommendation or a rating. In our Asia (ex-Australia and ex-India) and U.K. small- and mid-cap equity research, each stock’s expected total return is compared to the expected total return of a benchmark country market index, not to those analysts’ coverage universe. If it does not appear in the Important Disclosures section of this report, the certifying analyst’s coverage universe can be found on J.P. Morgan’s research website, www.jpmm.com.

J.P. Morgan Equity Research Ratings Distribution, as of July 04, 2020

	Overweight (buy)	Neutral (hold)	Underweight (sell)
J.P. Morgan Global Equity Research Coverage	46%	39%	15%
IB clients*	53%	49%	38%
JPMS Equity Research Coverage	43%	42%	15%
IB clients*	75%	70%	58%

*Percentage of subject companies within each of the "buy," "hold" and "sell" categories for which J.P. Morgan has provided investment banking services within the previous 12 months. Please note that the percentages might not add to 100% because of rounding.

For purposes only of FINRA ratings distribution rules, our Overweight rating falls into a buy rating category; our Neutral rating falls into a hold rating category; and our Underweight rating falls into a sell rating category. Please note that stocks with an NR designation are not included in the table above. This information is current as of the end of the most recent calendar quarter.

Disclosures

Equity Valuation and Risks: For valuation methodology and risks associated with covered companies or price targets for covered companies, please see the most recent company-specific research report at <http://www.jpmorganmarkets.com>, contact the primary analyst or your J.P. Morgan representative, or email research.disclosure.inquiries@jpmorgan.com. For material information about the proprietary models used, please see the Summary of Financials in company-specific research reports and the Company Tearsheets, which are available to download on the company pages of our client website, <http://www.jpmorganmarkets.com>. This report also sets out within it the material underlying assumptions used.

Analysts' Compensation: The research analysts responsible for the preparation of this report receive compensation based upon various factors, including the quality and accuracy of research, client feedback, competitive factors, and overall firm revenues.

Other Disclosures

J.P. Morgan is a marketing name for investment banking businesses of JPMorgan Chase & Co. and its subsidiaries and affiliates worldwide.

All research reports made available to clients are simultaneously available on our client website, J.P. Morgan Markets. Not all research content is redistributed, e-mailed or made available to third-party aggregators. For all research reports available on a particular stock, please contact your sales representative.

Any data discrepancies in this report could be the result of different calculations and/or adjustments.

Any long form nomenclature for references to China; Hong Kong; Taiwan; and Macau within this research report are Mainland China; Hong Kong SAR, China; Taiwan, China; Macau SAR, China.

Options and Futures related research: If the information contained herein regards options or futures related research, such information is available only to persons who have received the proper options or futures risk disclosure documents. Please contact your J.P. Morgan Representative or visit <https://www.theocc.com/components/docs/riskstoc.pdf> for a copy of the Option Clearing Corporation's Characteristics and Risks of Standardized Options or http://www.finra.org/sites/default/files/Security_Futures_Risk_Disclosure_Statement_2018.pdf for a copy of the Security Futures Risk Disclosure Statement.

Changes to Interbank Offered Rates (IBORs) and other benchmark rates: Certain interest rate benchmarks are, or may in the future become, subject to ongoing international, national and other regulatory guidance, reform and proposals for reform. For more information, please consult: https://www.jpmorgan.com/global/disclosures/interbank_offered_rates

Private Bank Clients: Where you are receiving research as a client of the private banking businesses offered by JPMorgan Chase & Co. and its subsidiaries ("J.P. Morgan Private Bank"), research is provided to you by J.P. Morgan Private Bank and not by any other division of J.P. Morgan, including but not limited to the J.P. Morgan corporate and investment bank and its research division.

Legal entity responsible for the production of research: The legal entity identified below the name of the Reg AC research analyst who authored this report is the legal entity responsible for the production of this research. Where multiple Reg AC research analysts authored this report with different legal entities identified below their names, these legal entities are jointly responsible for the production of this research.

Legal Entities Disclosures

U.S.: JPMS is a member of NYSE, FINRA, SIPC and the NFA. JPMorgan Chase Bank, N.A. is a member of FDIC. **Canada:** J.P. Morgan Securities Canada Inc. is a registered investment dealer, regulated by the Investment Industry Regulatory Organization of Canada and the Ontario Securities Commission and is the participating member on Canadian exchanges. **U.K.:** JPMorgan Chase N.A., London Branch, is authorised by the Prudential Regulation Authority and is subject to regulation by the Financial Conduct Authority and to limited regulation by the Prudential Regulation Authority. Details about the extent of our regulation by the Prudential Regulation Authority are available from J.P. Morgan on request. J.P. Morgan Securities plc (JPMS plc) is a member of the London Stock Exchange and is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. Registered in England & Wales No. 2711006. Registered Office 25 Bank Street, London, E14 5JP. **Germany:** This material is distributed in Germany by J.P. Morgan Securities plc, Frankfurt Branch which is regulated by the Bundesanstalt für Finanzdienstleistungsaufsicht and also by J.P. Morgan AG (JPM AG) which is a member of the Frankfurt stock exchange and is regulated by the Federal Financial Supervisory Authority (BaFin). JPM AG is a company incorporated in the Federal Republic of Germany with registered office at Taunustor 1, 60310 Frankfurt am Main, the Federal Republic of Germany. **South Africa:** J.P. Morgan Equities South Africa Proprietary Limited is a member of the Johannesburg Securities Exchange and is regulated by the Financial Services Board. **Hong Kong:** J.P. Morgan

Disclosures

Securities (Asia Pacific) Limited (CE number AAJ321) is regulated by the Hong Kong Monetary Authority and the Securities and Futures Commission in Hong Kong and/or J.P. Morgan Broking (Hong Kong) Limited (CE number AAB027) is regulated by the Securities and Futures Commission in Hong Kong. JP Morgan Chase Bank, N.A., Hong Kong is organized under the laws of U.S.A. with limited liability. **China:** J.P. Morgan Securities (China) Company Limited has been approved by CSRC to conduct the securities investment consultancy business. **Korea:** This material is issued and distributed in Korea by or through J.P. Morgan Securities (Far East) Limited, Seoul Branch, which is a member of the Korea Exchange (KRX) and is regulated by the Financial Services Commission (FSC) and the Financial Supervisory Service (FSS). **Australia:** J.P. Morgan Securities Australia Limited (JPMSAL) (ABN 61 003 245 234/AFS Licence No: 238066) is regulated by ASIC and is a Market, Clearing and Settlement Participant of ASX Limited and CHI-X. **Taiwan:** J.P. Morgan Securities (Taiwan) Limited is a participant of the Taiwan Stock Exchange (company-type) and regulated by the Taiwan Securities and Futures Bureau. **India:** J.P. Morgan India Private Limited (Corporate Identity Number - U67120MH1992FTC068724), having its registered office at J.P. Morgan Tower, Off. C.S.T. Road, Kalina, Santacruz - East, Mumbai – 400098, is registered with Securities and Exchange Board of India (SEBI) as a 'Research Analyst' having registration number INH000001873. J.P. Morgan India Private Limited is also registered with SEBI as a member of the National Stock Exchange of India Limited and the Bombay Stock Exchange Limited (SEBI Registration Number – INZ000239730) and as a Merchant Banker (SEBI Registration Number – MB/INM000002970). Telephone: 91-22-6157 3000, Facsimile: 91-22-6157 3990 and Website: www.jpmipl.com. For non local research reports, this material is not distributed in India by J.P. Morgan India Private Limited. **Thailand:** This material is issued and distributed in Thailand by JPMorgan Securities (Thailand) Ltd., which is a member of the Stock Exchange of Thailand and is regulated by the Ministry of Finance and the Securities and Exchange Commission and its registered address is 3rd Floor, 20 North Sathorn Road, Silom, Bangrak, Bangkok 10500. **Indonesia:** PT J.P. Morgan Sekuritas Indonesia is a member of the Indonesia Stock Exchange and is regulated by the OJK a.k.a. BAPEPAM LK. **Philippines:** J.P. Morgan Securities Philippines Inc. is a Trading Participant of the Philippine Stock Exchange and a member of the Securities Clearing Corporation of the Philippines and the Securities Investor Protection Fund. It is regulated by the Securities and Exchange Commission. **Brazil:** Banco J.P. Morgan S.A. is regulated by the Comissão de Valores Mobiliários (CVM) and by the Central Bank of Brazil. **Mexico:** J.P. Morgan Casa de Bolsa, S.A. de C.V., J.P. Morgan Grupo Financiero is a member of the Mexican Stock Exchange and authorized to act as a broker dealer by the National Banking and Securities Exchange Commission. **Singapore:** This material is issued and distributed in Singapore by or through J.P. Morgan Securities Singapore Private Limited (JPMSS) [MCI (P) 018/04/2020 and Co. Reg. No.: 199405335R], which is a member of the Singapore Exchange Securities Trading Limited and/or JPMorgan Chase Bank, N.A., Singapore branch (JPMCB Singapore) [MCI (P) 070/09/2019], both of which are regulated by the Monetary Authority of Singapore. This material is issued and distributed in Singapore only to accredited investors, expert investors and institutional investors, as defined in Section 4A of the Securities and Futures Act, Cap. 289 (SFA). This material is not intended to be issued or distributed to any retail investors or any other investors that do not fall into the classes of "accredited investors," "expert investors" or "institutional investors," as defined under Section 4A of the SFA. Recipients of this document are to contact JPMSS or JPMCB Singapore in respect of any matters arising from, or in connection with, the document. **Japan:** JPMorgan Securities Japan Co., Ltd. and JPMorgan Chase Bank, N.A., Tokyo Branch are regulated by the Financial Services Agency in Japan. **Malaysia:** This material is issued and distributed in Malaysia by JPMorgan Securities (Malaysia) Sdn Bhd (18146-X) which is a Participating Organization of Bursa Malaysia Berhad and a holder of Capital Markets Services License issued by the Securities Commission in Malaysia. **Pakistan:** J. P. Morgan Pakistan Broking (Pvt.) Ltd is a member of the Karachi Stock Exchange and regulated by the Securities and Exchange Commission of Pakistan. **Dubai:** JPMorgan Chase Bank, N.A., Dubai Branch is regulated by the Dubai Financial Services Authority (DFSA) and its registered address is Dubai International Financial Centre - Building 3, Level 7, PO Box 506551, Dubai, UAE. **Russia:** CB J.P. Morgan Bank International LLC is regulated by the Central Bank of Russia. **Argentina:** JPMorgan Chase Bank Sucursal Buenos Aires is regulated by Banco Central de la República Argentina ("BCRA"- Central Bank of Argentina) and Comisión Nacional de Valores ("CNV"- Argentinian Securities Commission")

Country and Region Specific Disclosures

U.K. and European Economic Area (EEA): Unless specified to the contrary, issued and approved for distribution in the U.K. and the EEA by JPMS plc. Investment research issued by JPMS plc has been prepared in accordance with JPMS plc's policies for managing conflicts of interest arising as a result of publication and distribution of investment research. Many European regulators require a firm to establish, implement and maintain such a policy. Further information about J.P. Morgan's conflict of interest policy and a description of the effective internal organisations and administrative arrangements set up for the prevention and avoidance of conflicts of interest is set out at the following link <https://www.jpmorgan.com/jpmpdf/1320742677360.pdf>. This report has been issued in the U.K. only to persons of a kind described in Article 19 (5), 38, 47 and 49 of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005 (all such persons being referred to as "relevant persons"). This document must not be acted on or relied on by persons who are not relevant persons. Any investment or investment activity to which this document relates is only available to relevant persons and will be engaged in only with relevant persons. In other EEA countries, the report has been issued to persons regarded as professional investors (or equivalent) in their home jurisdiction. **Australia:** This material is issued and distributed by JPMSAL in Australia to "wholesale clients" only. This material does not take into account the specific investment objectives, financial situation or particular needs of the recipient. The recipient of this material must not distribute it to any third party or outside Australia without the prior written consent of JPMSAL. For the purposes of this paragraph the term "wholesale client" has the meaning given in section 761G of the Corporations Act 2001. J.P. Morgan's research coverage universe spans listed securities across the ASX All Ordinaries index, securities listed on offshore markets, unlisted issuers and investment products which Research management deem to be relevant to the investor base from time to time. J.P. Morgan seeks to cover companies of relevance to the domestic and international investor base across all GIC sectors, as well as across a range of market capitalisation sizes. **Germany:** This material is distributed in Germany by J.P. Morgan Securities plc, Frankfurt Branch which is regulated by the Bundesanstalt für Finanzdienstleistungsaufsicht. **Korea:** This report may have been edited or contributed to from time to time by affiliates of J.P. Morgan Securities (Far East) Limited, Seoul Branch. **Singapore:** As at the date of this report, JPMSS is a designated market maker for certain structured warrants listed on the Singapore Exchange where the underlying securities may be the securities discussed in this report. Arising from its role as designated market maker for such structured warrants, JPMSS may conduct hedging activities in respect of such underlying securities and hold or have an interest in such underlying securities as a result. The updated list of structured warrants for

Disclosures

which JPMSS acts as designated market maker may be found on the website of the Singapore Exchange Limited: <http://www.sgx.com>. In addition, JPMSS and/or its affiliates may also have an interest or holding in any of the securities discussed in this report – please see the Important Disclosures section above. For securities where the holding is 1% or greater, the holding may be found in the Important Disclosures section above. For all other securities mentioned in this report, JPMSS and/or its affiliates may have a holding of less than 1% in such securities and may trade them in ways different from those discussed in this report. Employees of JPMSS and/or its affiliates not involved in the preparation of this report may have investments in the securities (or derivatives of such securities) mentioned in this report and may trade them in ways different from those discussed in this report. **Taiwan:** Research relating to equity securities is issued and distributed in Taiwan by J.P. Morgan Securities (Taiwan) Limited, subject to the license scope and the applicable laws and the regulations in Taiwan. According to Paragraph 2, Article 7-1 of Operational Regulations Governing Securities Firms Recommending Trades in Securities to Customers (as amended or supplemented) and/or other applicable laws or regulations, please note that the recipient of this material is not permitted to engage in any activities in connection with the material which may give rise to conflicts of interests, unless otherwise disclosed in the “Important Disclosures” in this material. **India:** For private circulation only, not for sale. **Pakistan:** For private circulation only, not for sale. **New Zealand:** This material is issued and distributed by JPMSAL in New Zealand only to “wholesale clients” (as defined in the Financial Advisers Act 2008). The recipient of this material must not distribute it to any third party or outside New Zealand without the prior written consent of JPMSAL. **Canada:** This report is distributed in Canada by or on behalf of J.P.Morgan Securities Canada Inc. The information contained herein is not, and under no circumstances is to be construed as an offer to sell securities described herein, or solicitation of an offer to buy securities described herein, in Canada or any province or territory thereof. The information contained herein is under no circumstances to be construed as investment advice in any province or territory of Canada and is not tailored to the needs of the recipient. **Dubai:** This report has been distributed to persons regarded as professional clients or market counterparties as defined under the DFSA rules. **Brazil:** Ombudsman J.P. Morgan: 0800-7700847 / ouvidoria.jp.morgan@jpmorgan.com.

General: Additional information is available upon request. Information has been obtained from sources believed to be reliable but JPMorgan Chase & Co. or its affiliates and/or subsidiaries (collectively J.P. Morgan) do not warrant its completeness or accuracy except with respect to any disclosures relative to JPMS and/or its affiliates and the analyst's involvement with the issuer that is the subject of the research. All pricing is indicative as of the close of market for the securities discussed, unless otherwise stated. Opinions and estimates constitute our judgment as of the date of this material and are subject to change without notice. Past performance is not indicative of future results. This material is not intended as an offer or solicitation for the purchase or sale of any financial instrument. The opinions and recommendations herein do not take into account individual client circumstances, objectives, or needs and are not intended as recommendations of particular securities, financial instruments or strategies to particular clients. The recipient of this report must make its own independent decisions regarding any securities or financial instruments mentioned herein. JPMS distributes in the U.S. research published by non-U.S. affiliates and accepts responsibility for its contents. Periodic updates may be provided on companies/industries based on company specific developments or announcements, market conditions or any other publicly available information. Clients should contact analysts and execute transactions through a J.P. Morgan subsidiary or affiliate in their home jurisdiction unless governing law permits otherwise.

"Other Disclosures" last revised July 04, 2020.

Copyright 2020 JPMorgan Chase & Co. All rights reserved. This report or any portion hereof may not be reprinted, sold or redistributed without the written consent of J.P. Morgan.