SWTEST

PROBE TODAY, FOR TOMORROW

2022 CONFERENCE

The semiconductor industry is fast adapting to a new reality. How can suppliers of probe cards keep up?

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Overview

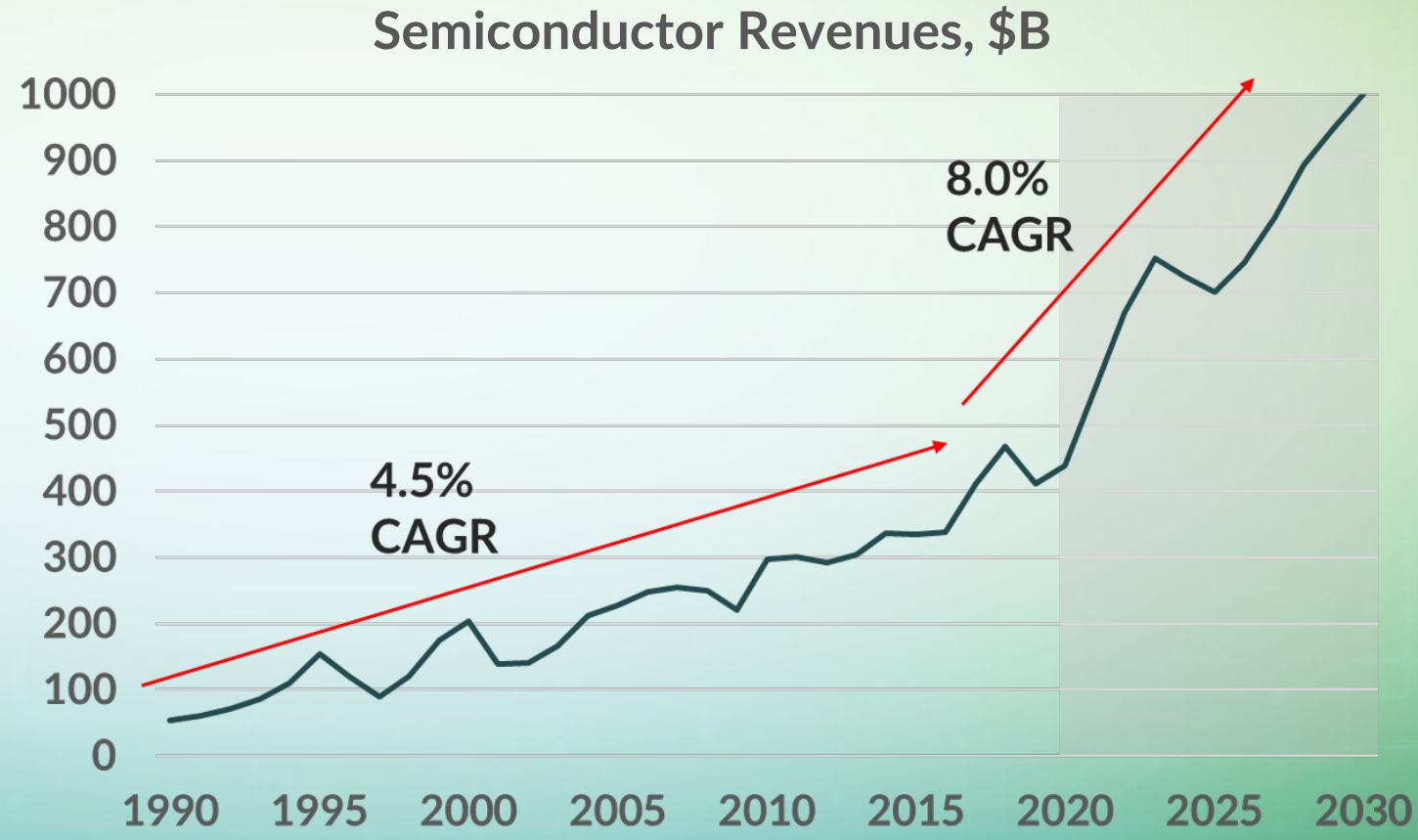
- Powerful forces are acting on the semiconductor industry!
- What this means for the semiconductor supply chain ?
- How will influence probe card market?

Semiconductor Super Cycle

On track to beat 1 trillion USD by 2030

2 Factors in play:

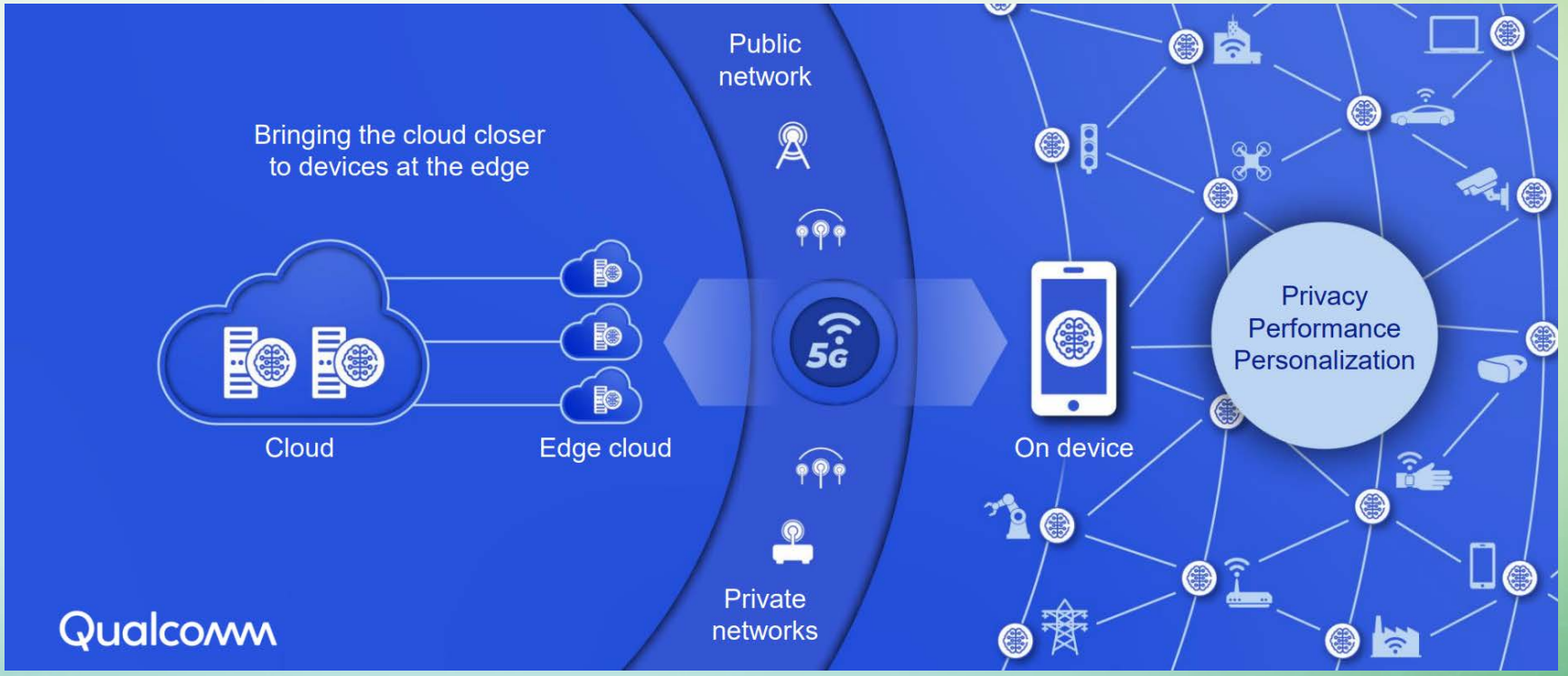
- COVID-19 has accelerated the adoption of digital technologies by several years
- Clear manufacturing technology roadmap to 1nm (Equipment, materials, device architectures, and packaging technologies)



Industry Doubling in Ten Years

Distributed computing enabled by 5G

- It's a data centric world – no longer driven by human consumption alone
- Silicon content (cm^2) of electronic devices is increasing
- Majority of the distributed network involves More than Moore devices

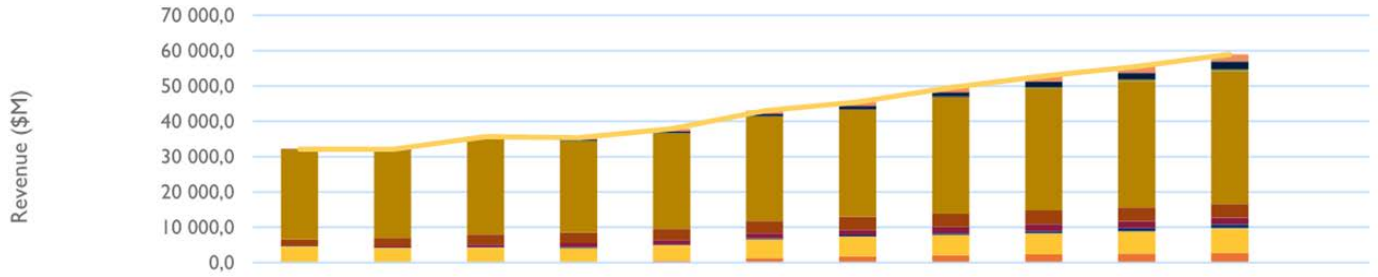


Strong Growth Across Multiple Segments

Example - Mobile & Consumer – SoC by end-system, $M

- In terms of processor revenue, smartphone will stay by far the most important market, with more than 60% of the total SOC revenue in 2026
- 7 end-systems are expected to exceed $1B each in 2026

2016 - 2026 Mobile and consumer SoC revenue forecast by end-system



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	CAGR 20-26
Smartwatches	187,8	264,9	352,2	496,4	685,7	849,0	1 066,4	1 288,4	1 557,3	1 756,2	1 954,6	19,1%
Headset On & Over	51,3	71,5	91,1	107,4	117,0	131,5	146,7	162,6	179,3	196,8	215,2	10,7%
TWS Earbuds	4,3	17,4	79,3	278,6	413,6	573,7	794,7	1 034,3	1 310,0	1 573,9	1 858,3	28,5%
C. VR Headset	0,0	23,9	49,2	78,9	116,5	158,9	274,3	344,7	360,8	364,0	407,7	23,2%
C. AR Headset	0,0	0,0	0,7	5,5	8,6	18,3	32,6	81,7	165,5	311,9	339,5	84,5%
Smartphones	25 418,1	24 790,1	27 103,8	25 979,7	27 003,5	29 489,4	30 206,0	32 821,7	34 548,7	35 747,1	37 573,1	5,7%
Smart TVs	1 887,5	2 398,2	2 898,4	2 969,1	3 217,7	3 556,7	3 719,5	3 796,7	3 892,6	3 963,5	3 925,8	3,4%
Smart speakers	105,8	322,6	766,8	1 176,9	1 310,7	1 428,9	1 575,9	1 776,2	1 997,3	1 990,0	1 916,7	6,5%
Security Camera	16,8	51,5	75,0	109,0	128,5	194,8	274,5	367,7	492,8	748,1	935,0	39,2%
Personal Robotics	16,8	26,5	39,2	48,3	66,0	79,8	99,5	120,7	146,3	177,2	215,2	21,8%
Consumer Drones	124,4	177,6	143,8	112,0	86,1	75,8	66,5	61,3	60,0	62,5	66,2	-4,3%
Tablets	4 377,5	3 934,9	3 963,6	3 865,2	4 256,1	5 169,0	5 507,4	5 620,2	5 871,5	6 163,4	6 828,3	8,2%
APU based Laptop	21,8	53,7	90,5	136,8	504,0	1 293,7	1 732,7	2 071,7	2 285,6	2 533,3	2 723,8	32,5%
Total	32 212,1	32 132,8	35 653,5	35 363,8	37 914,2	43 019,6	45 496,7	49 548,1	52 867,5	55 587,9	58 959,3	7.6%

Industry Doubling in Ten Years

Surge in demand stretching supply chains to breaking point

- **Fab builders are sold out for 2 years**
- **Wafer Fab Equipment manufacturers' lead times are extending**
  - Some key WFE manufacturers have reached maximum capacity
  - Key subsystems and components suppliers unable to keep up
  - COVID-19 still affecting supply
  - Chip shortage now affecting WFE manufacturers
  - Relocation of supply chains away from China adding to the problem
  - Equipment prices going up
- **These constraints are limiting growth but will reduce the severity of the next downturn**
- **Chip shortages have exposed supply chain risks and regional dependencies**

Chip Shortages Expose Supply Chain Risks

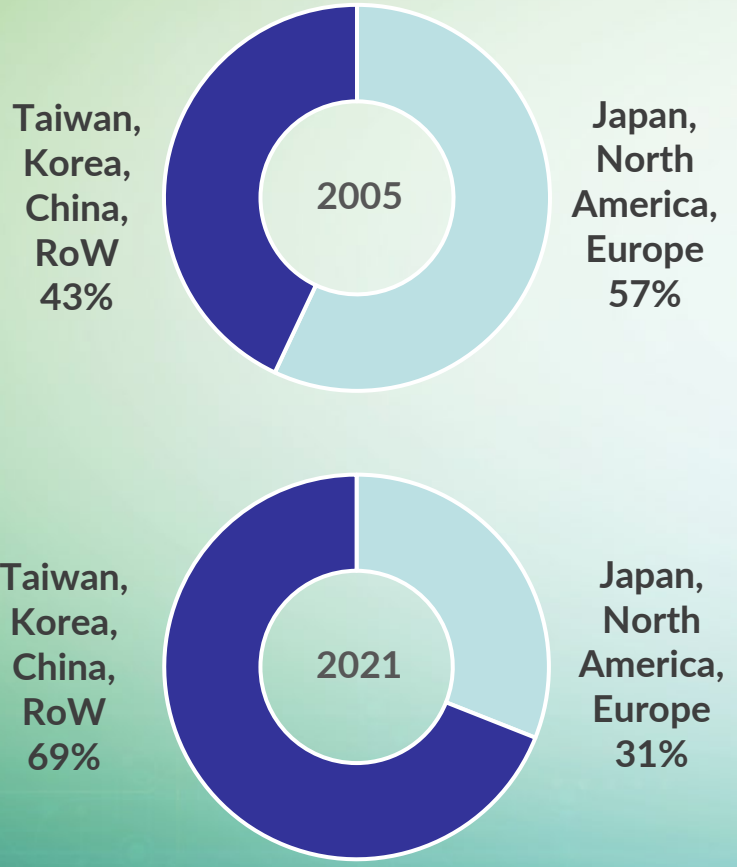
Governments are taking a long and hard look at dependencies

- **COVID-19 and US-China trade war are the catalysts for government action**
- **Majority of leading-edge chip manufacturing is now in South Korea and Taiwan**
- **What about the rest of the semiconductor supply chain?**
  - Chip design software
  - Wafer Fab Equipment
  - Test Equipment
  - Assembly Equipment
  - Specialist subsystems and components used on Wafer Fab Equipment
  - Test consumables – probe cards, test sockets and advanced PCBs
  - Materials

Should we be worried?

Chipmaking Shifting to Korea, Taiwan, and China

Manufacturing capacity (wafer area) by region



- **Manufacturing of advanced chips (=< 7nm) - Taiwan (TSMC) and South Korea (Samsung)**
- US losing/lost the lead in manufacturing know-how
- EU at 20nm
- Japan – non-memory manufacturing at 40nm
- **US, EU and Japanese Government incentives are changing as they now understand the risks**

Public data from ESIA, Knometa Researh

Semiconductor Supply Chain

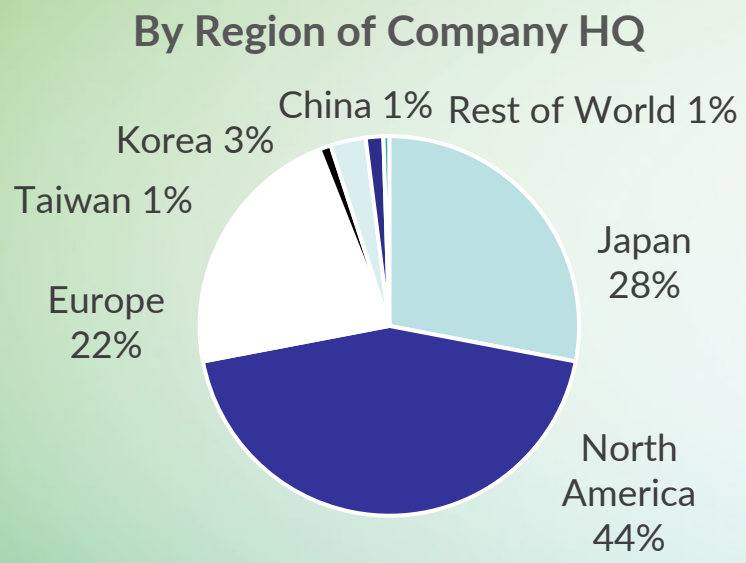
Majority of intellectual property belongs to US, EU, and Japanese suppliers

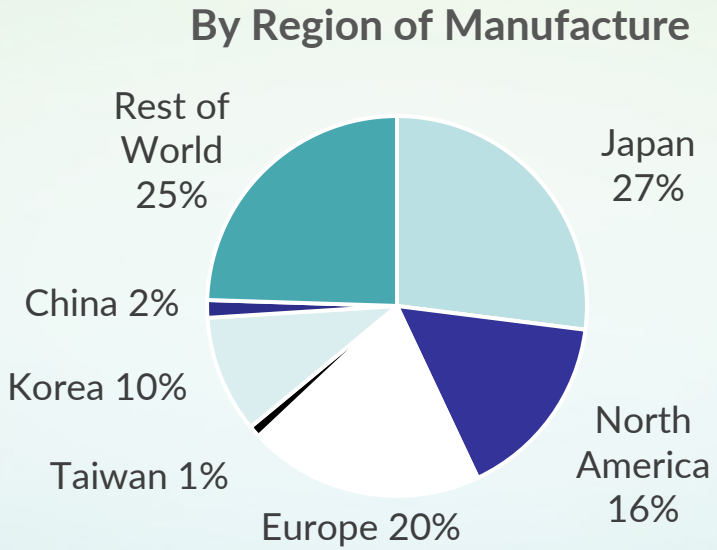
- **Chip design software:**
  (Synopsys, Mentor Graphics)
- **Wafer Fab Equipment:**
  (AMAT, LAM, ASML, KLA, TEL)
- **Test Equipment:**
  (Teradyne, Advantest)
- **Assembly Equipment:**
  (ASM Pacific, BESI)
- **Specialist subsystems and components used on Wafer Fab Equipment:**
  (Edwards, MKS, AEI)
- **Test consumables – probe cards, test sockets, and advanced PCBs:**
  (FormFactor, Technoprobe, MJC)
- **Materials, etc.**

But where are they being made?

Wafer Fab Equipment Shifting to Southeast Asia

Supplier HQ vs. Location of Manufacturing by Region 2021





- US OEMs (Applied Materials, Lam Research and KLA) aggressively offshoring manufacturing to Singapore and Malaysia. R&D and decision making also moving to South East Asia
- Their key suppliers, also with HQs in US, EU and Japan, are moving manufacturing to Singapore, Malaysia, Korea and China.

- **Latest announcements indicate significant shift of equipment manufacturing back to US**
- **Other parts of the supply chain have similar characteristics**

Geopolitical Forces

Re-evaluation of the cost vs. risk equation

Localisation
- protect local technology sovereignty
- develop local supply chains, establish own ecosystem

- **US, EU, and Japan**
  - Attract Intel, Samsung and TSMC
  - Re-shore
  - Limit China's access to technology

- **Korea and Taiwan**
  - Invest in overseas manufacturing
  - Maintain lead in manufacturing technology

- **Swift reaction from China**
  - Significant investment in R&D
  - Bring in overseas talents

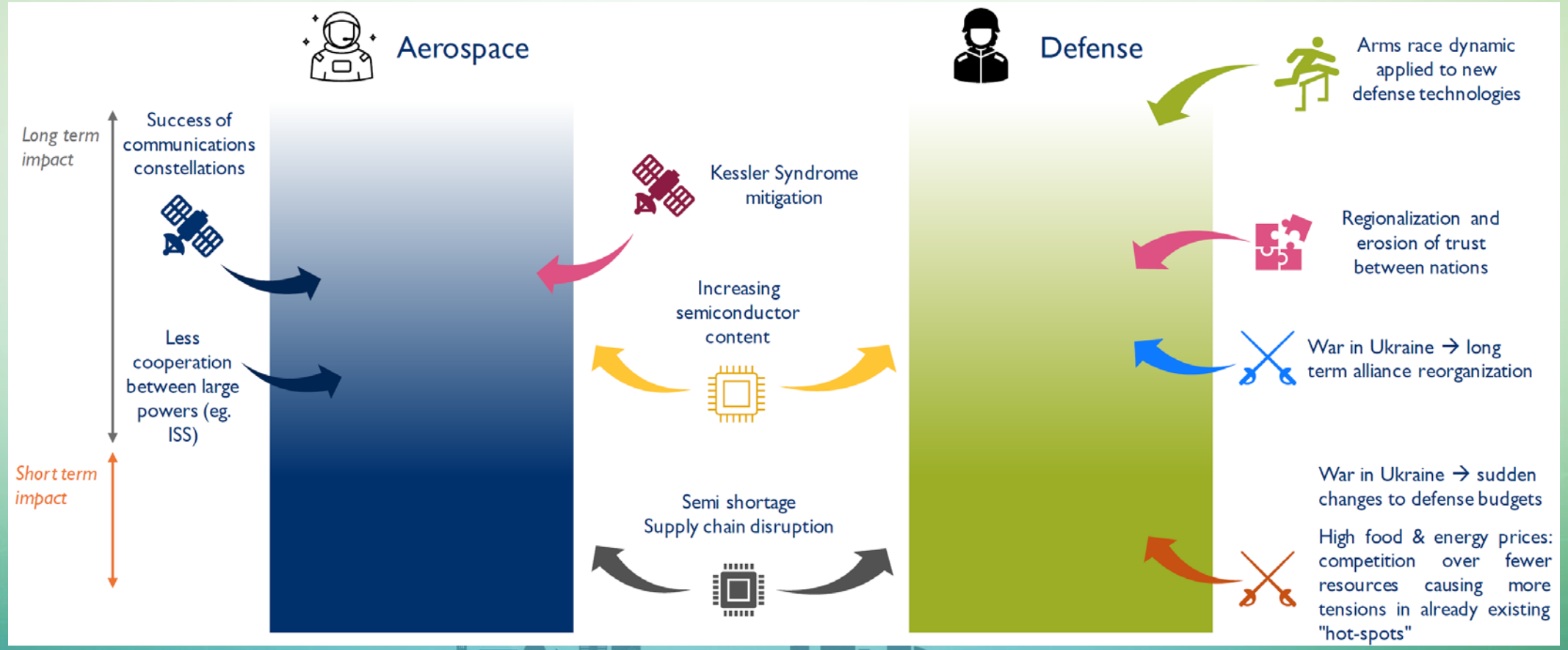
2022 New Added Force

Following Russian / Ukraine War, a new world order is emerging

- The global **defense spending** has reached **$2.1T** in 2021 with a **0.7%** increase from 2020, surpassing two trillion dollars for the first time in history.
- The **Space market** is **expanding**, driven by defense programs, new customer approaches (communication, space tourism), and renewals of major space programs.
- The 2021 Defense and Aerospace semiconductor market represented **1%** of the total semiconductor market, representing **$5.8B** of a $555B total.
- The 2021 Defense and Aerospace semiconductor market consumed **3.8%** of the total semiconductor probe cards, representing **$0.1B** of a $2.57B.
- Regionalization and increased semiconductor content are the main long-term evolutions for the defense and space applications.

Long Term and Short Term Evolutions

Inside & outside forces that will have a durable effect on the Aerospace and Defense Industries



Disruption Ahead

Semiconductor industry is getting pulled out of shape…

- **Risk of overcapacity by 2024**
- **Higher prices due to relocation of manufacturing to higher cost regions**
- **Duplication of resources to offset supply risks are adding to costs**
- **Larger inventories to reduce supply chain shocks adding to costs**
- **Supply chains on the move - relocation**
- **Changing government strategies**

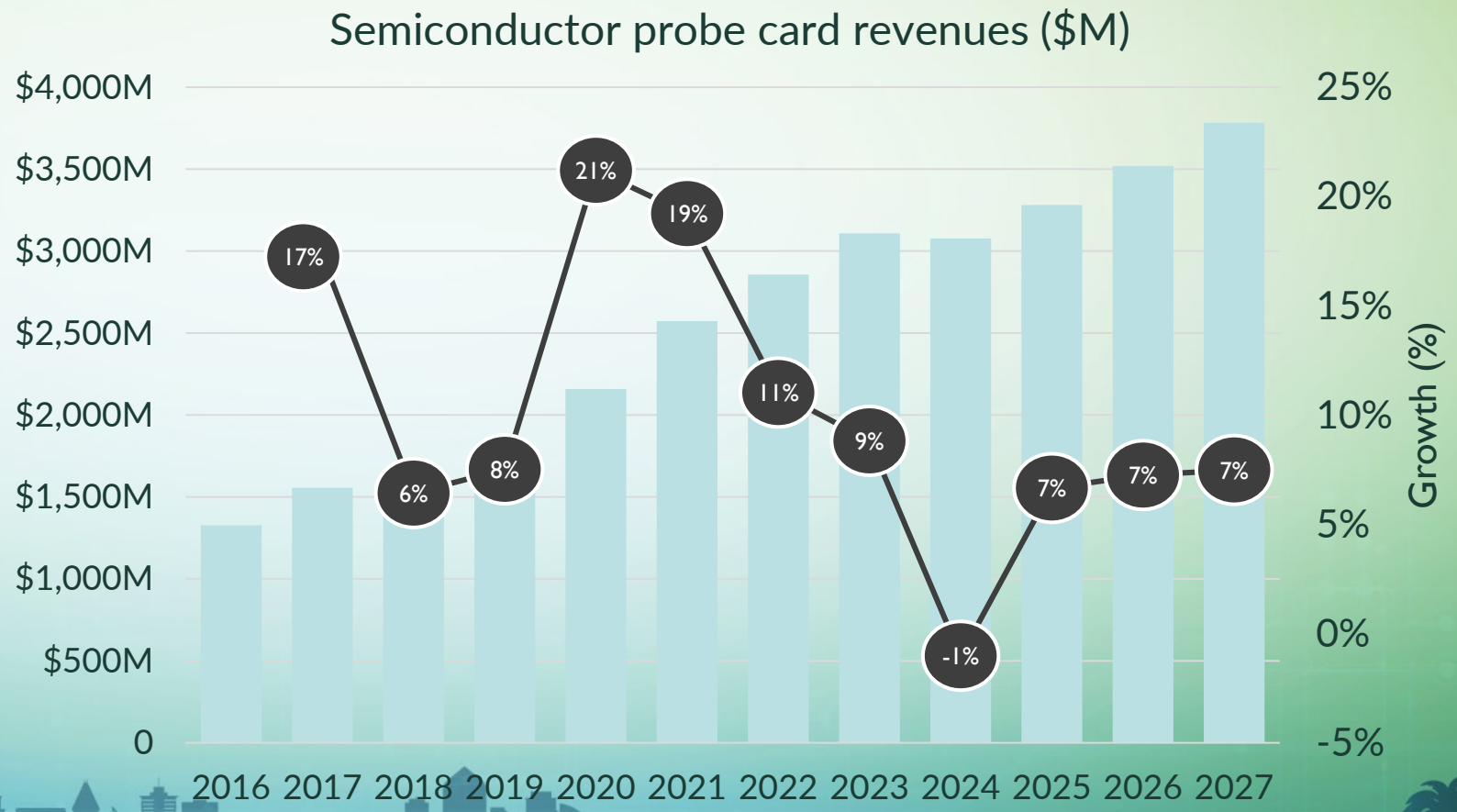
- Russia has new plans to ramp up local production from 90 nm at the end of 2022 to 28 nm by 2030
- Spain wants to invest $12.4 Billion in chips
- TSMC starts construction for new chip fab in Japan in April 2022

…but will eventually settle into a new pattern

Annual Sales of Probe Cards, $M

Continued double digit growth following 2020

- **Revenue growth** in 2021 would have been **greater** if the supply chain were able to respond faster.
- In the end, **sales** increased **19%**, which was well above the **long-term growth** rate of around **14%**.
- General price increases across the board and inventory builds were contributing factors. Prices for probe cards used in some leading-edge applications attracted premium pricing.



Probe Card Market Dynamics

Market Overview 2021

- **Semiconductor probe card revenues continue to break away from the long-term trend**
  - Revenue exceeded $2.5Bn in 2021
  - Double digit growth for a third year in a row forecast for 2022
  - Revenues to reach $2.86Bn in 2022
  - Long-term growth trend of 5.8% will result in a market of $3.78Bn by 2027

- **Vertical probe cards making a comeback**
  - Vertical probe card technology gaining success in logic, power, and RF applications
  - The switch away from cantilever and vertical probe cards to MEMS probe cards is slowing
  - MEMS probe card revenues are stabilizing at 69% of total semiconductor probe card revenues

- **Over 50 suppliers active in the market**
  - Chinese suppliers gaining traction in the MEMS probe card market
  - Impact of US-China trade dispute having a measurable impact on US suppliers

Probe Card Market Dynamics

Market Drivers - Next 5 to 10 Years

	2016 - 2021 CAGR	2022 - 2027 CAGR
Processors	10.5%	6.5%
Sensors	12.1%	7.1%
RF	9.2%	4.9%
SiC and GaN Devices	22.8%	35.2%
DRAM	18.0%	9.1%
NAND	13.6%	5.9%

- **Memory** is an important market and reliably accounts for over one-third of probe card revenues. **DRAM** and **NAND** are forecast to continue growing at healthy compound annual growth rates of **9.1%** and **5.9%**, respectively, for the next five years.

- **Non-memory** market drivers are all **positive** and set for continuous growth over the next five years.

- **Processors** for mobile and AI applications using advanced technology nodes are driving demand for fine pitch leading-edge probe card technologies.

- **Sensors** and **RF** are critical drivers for MEMS and the specialty probe card businesses.

Navigating the Turbulence and Exploiting Opportunities

Call to action

- **Get to up-to-date market research**
- **Be pro-active**
- **Think big, act smart**