Testimony Before U.S.-China Economic and Security Review Commission June 5, 2025 David Schild, Executive Director, The Printed Circuit Board Association of America

Printed circuit boards are the foundational infrastructure of modern electronics. They serve as the essential platform connecting semiconductors to electronic devices, enabling functionality in everything from smartphones and automobiles to defense systems and medical equipment. Without PCBs, semiconductors cannot operate—highlighting the necessity of a robust and secure PCB manufacturing base to ensure the integrity of our technological ecosystem.

- 1. Provide a brief overview of the supply chain for printed circuit boards (PCBs) and their geographic distribution. How did China and East Asia become so dominant in the PCB supply chain? What production still occurs inside the United States?
 - <u>The details of production</u>. PCB manufacturers use raw materials such as copper-clad laminates, copper foils, prepregs, and resins. Copper-clad laminates provide a rigid structure, while copper foils create conductive 'tracks' for the circuit layout. Prepregs, a type of fiberglass imbued with resin, serve as a bonding agent for multilayer PCBs. This process includes multiple steps, such as laser drilling, laser direct imaging (LDI), etching, electroplating, and lamination. The final product is a bare PCB. Following fabrication, PCB assembly is the process of mounting electronic components onto a printed circuit board to create a functional device. After being assembled, the PCBs are prepared for integration into an array of electronic products, from smartphones and computers to defense systems, home appliances and vehicles. Advanced technology PCBs (High Density Interconnect (HDI) and Ultra High Density Interconnect (uHDI) are required to support data server advanced microelectronics architecture that provides the processing capability of Artificial Intelligence (AI) capability in the U.S. This illustration shows the technology "stack" needed to connect to an end use device.



 <u>Asia gained manufacturing prominence</u> as domestic OEMs migrated their electronics production to Asia and other Low Cost Regions to create increased profitability. The production costs were lower due to a lower labor rate structure and decades of consistent government subsidies. China in particular has stated their intention to dominate microelectronics manufacturing. Asian government's support made it impossible for American companies to compete effectively.

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- <u>The American PCB Manufacturing Base.</u> The U.S. once produced nearly 30 percent of the world's PCBs. Today the number is 4 percent. For substrates, we now make less than one percent. Over the past 30 years PCB production has moved to other countries, primarily in Asia, where 90 percent of PCBs are now made.
- The result was that many U.S. PCB companies went out of business and there was significant industry consolidation. As recently as the year 2000, there were over 2,000 PCB companies in the U.S. By most estimates, today there are less than 145 U.S. PCB fabricator operations A closer examination of that facility count reveals a highly fragmented market with the Top 10 U.S. fabricators likely holding the majority of the market. These dynamics are even more pronounced when viewed through a defense PCB supply chain prism as not all U.S. PCB fabricators are certified to build defense certified PCBs . Advanced technology PCB manufacturing costs to support the smallest geometries, advanced via constructions and military compliance, combined with cybersecurity compliance (NIST 800-171 and CMMC 2.0) are extraordinarily high and prohibitive to all except the fabricators operating at scale that have access to capital for continual CAPEX investment.
- 2. <u>Dependence on other nations</u>. This dependence on other countries creates risk for both our economic and national security. How dependent is the U.S. economy on China for PCB manufacturing, and what the national security risks does this reliance pose to the United States?

• <u>Economic and national security risk.</u> Asia produces 90 percent of the world's PCBs – more than 50 percent from China alone. China mass produces commoditized PCBs that power automotive and a host of commercial electronic systems. China also dominates the high-end of the value chain and is far ahead of the U.S. in production of Ultra High Density (uHDI) PCBs used in complex systems, such as data servers in support of Artificial Intelligence (AI) processing.

• The national security and critical infrastructure risks are profound. Congress included guidance in the FY 2022 National Defense Authorization Act Section 851 that requires the Department of Defense to have a plan by 2027 to remove from the defense supply chain all dual-use components originating in China, Russia, Iran and North Korea. What is missing are restrictions on Chinese components that live in our critical infrastructure: air traffic control, medical systems, banking, telecommunications, the electric grid, and others.

- 3. What are the primary barriers to expanding domestic PCB manufacturing capacity? Which countries offer viable alternatives to Chinese-made PCBs?
 - A primary barrier to expanding domestic PCB manufacturing is not having a reliable demand signal from commercial and defense PCB buyers that would provide the ability to plan and instill private investment confidence. By our estimates, the defense industry accounts for approximately 40 percent of the U.S. PCB industry. U.S. PCB manufacturers companies serving the trusted and secure PCBs for the defense industry are operating at record capacity consumption levels and would be unable to scale up in a time of crisis. Funding as proposed in the PCBS Act for infrastructure build-out would ideally be made available to specialized manufacturers in the defense PCB sector. These companies have made private investment, are performing at a high level on DoD Programs of Record, have a demonstrated track record of success in meeting DoD prime requirements,

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deploy engineering teams that can quickly implement the required process methodologies, have experience with the advanced equipment sets required to produce robust defense certified PCBs and are led by experienced senior management teams with decades of experience.

- There is an urgent need for new brick-and-mortar, state of the art facility greenfield expansion to support defense PCB manufacturing. It is important to note that zero new facilities for defense manufacturing have been established in the past twenty plus years in the U.S. New PCB facilities that have come online during this period have all been captive, i.e.; created to build product for a singular private entity (examples include Space X in Bastrop, TX, Schweitzer Engineering Laboratories in Moscow, ID and Greensource (Whelen Engineering) in Charlestown, NH). Absent government investment in defense centric PCB capabilities, there is insufficient confidence in an appropriate return on investment (ROI) by private companies to make these investments. The rest of the domestic PCB manufacturers serving critical infrastructure and other industry verticals don't have the demand signal that makes the non-defense related companies an attractive investment. These suppliers both compete with China, and have integrated China-based fabricators into their go-to-market strategy by outsourcing U.S. commercial requirements direct to Chinese fabricators and reselling with margin addition (brokering), or outsourcing the materials and lamination intensive processes to China and then finalizing the manufacturing in their U.S. facilities (mass lamination) Without government policies and legislation providing investment in critical infrastructure, such as detailed in the Protecting Circuit Boards and Substrates Act (PCB Act), introduced on May 23, 2025 into the 119th Congress on a bipartisan basis, these dynamics will not change.
- Standard solutions offered for offshored industries. One option is "China plus One". It means having other sources in addition to China. We accept that there will always be some commoditized microelectronics sourced from China and/or China plus One. However, we must have a trusted and secure supply chain for national defense and critical infrastructure. We are not concerned if our toaster has a PCB from China contained in it, but there have been multiple, well-documented reports of nefarious capability insertion in China fabricated PCBs and assemblies into our critical infrastructure and China has proven untrustworthy. Therefore, China Plus One is not a cure all. It is only one of the risk reduction measures being implemented.
- **"Friendshoring**" is another approach being discussed. This means reducing risk by sourcing key products from friendly nations less likely to be subject to the whims of autocratic regimes. The catch is that many of these friendly countries are still at the end of long and dangerous supply chains that have been interrupted by pirates, regional wars, shipping channel blockages, and extreme weather.
- **"Nearshoring**" combines geographic proximity with ongoing government to government trade arrangements, with Mexico and Canada (USMCA) as an example.
- **Complicating alternatives are tariffs.** The rapidly changing tariff implementation the administration is pursuing bears watching. However, one thing is sure. As we have offshored PCB manufacturing to a large degree over the past three decades, supply

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chains for materials and equipment have followed. Many inputs required to produce PCBs are only available from the very countries subject to tariffs. Overall costs for U.S. PCB manufacturers absolutely increase in this scenario. In simple terms, this approach will make domestic manufacturers less competitive even if they are sourcing outside of China from friendly nations.

- 4. What chokepoints or single points of failure exist in U.S. supply chains? How dependent are U.S. PCB manufacturers on machine tools, tooling, and other critical manufacturing equipment produced in China?
 - The PCB industry relies on a global supply chain. The PCB supply chain is comprised of critical base materials providers, highly specialized chemistries, machines and tools (many only produced in Europe or Asia), and capital intensive manufacturing facilities. This industry also depends on a skilled workforce and the research and development needed to keep American intellectual property competitive.
 - There are single points of failure in the supply chain. For example, we have only one copper foil producer in the U.S. In November 2024, it was announced that Denkai America (Japanese ownership) was closing the <u>last remaining copper foil manufacturing operation that remained in the U.S.</u> Fortunately, a U.S. buyer for the operation emerged (now operating as Camden Copper in South Carolina).. Likewise, other supply chain nodes are also single points of failure, to include woven glass, integrated circuit substrates, dry film photo resist, etching equipment, laser and mechanical drilling systems. All of these are required to create cutting edge PCBs.
- 5. How does a reliance on offshore PCB manufacturing affect the resiliency of U.S. defense supply chains? How effective have export controls proven in preventing U.S. PCB technology from contributing to Chinese military modernization efforts?

As U.S. producers continue to lose non-defense market share to offshore PCB fabricators, domestic growth investment slows, and upstream supply chains reorganize to support this global migration vs. our domestic needs. The decline in commercial products manufacturing in the U.S. creates a technology lag for the U.S. PCB industry and for our defense customers. The newest innovations in PCB design, circuit density, process methodologies, equipment and materials are driven by commercial OEMs and these products are increasingly built offshore. Not building these new commercial designs results in U.S. manufacturers having to co-develop new capabilities alongside defense OEM's vs. already having the capabilities developed if they were supporting new commercial designs 1-2 years earlier.

New manufacturing equipment and materials innovation and deployment: R&D and new equipment introduction focuses on the geographical area of highest demand density. As a result, the newest and most capable equipment and materials are increasingly introduced in China well ahead of other geographies.

Export controls largely work to prevent defense-related designs from leaving the U.S., but the scope of export controls should be expanded to include all elements of critical U.S. infrastructure. This is a national security imperative.

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There are 16 critical infrastructure sectors identified in Presidential Policy Directive 21 whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof. As reference, please see text of (PPD-21): Critical Infrastructure Security and Resilience which advances a national policy to strengthen and maintain secure, functioning, and resilient critical infrastructure.

6. What advantages do Chinese PCB makers possess in innovation and leading-edge PCB technologies? How has China's PCB industry contributed to the growth of China's OEMs, including through intellectual property theft?

Chinese PCB makers have the advantage of supportive government policy over decades. Here are the policies and government actions that contributed to the current situation.

Made in China 2025

- Introduced in 2015, this Chinese national strategy explicitly targeted high-tech industries, including **advanced electronics manufacturing**, as key pillars for economic transition.
- PCBs, being foundational to almost all electronic products, were indirectly but crucially affected by this policy, as the government sought to **boost self-sufficiency and local capabilities** in core components.

Strategic Industry Classification

- The PCB industry falls under "strategic emerging industries" in China, qualifying it for preferential tax treatment, subsidies, low-interest loans, and fast-track approvals for land use and environmental clearances.
- Provinces like Guangdong, Jiangsu, and Sichuan created **industry-specific development zones** focusing on electronics manufacturing.

World-Class Infrastructure

 Specialized industrial parks were developed to co-locate PCB manufacturers with upstream and downstream firms, such as copper-clad laminate producers, surface mount tech (SMT) suppliers, and OEM assembly lines.

Vertical Integration of the Supply Chain

• Government support for upstream materials (like copper foils, resins, and laminates) and downstream assembly (EMS companies) has ensured raw material availability and cost efficiency, reducing dependence on imports.

Trade and Export Incentives

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Export Processing Zones and FTZs

- Many PCBs are manufactured in **Export Processing Zones (EPZs) or Free Trade Zones** (FTZs) where duty-free access to imported raw materials and simplified customs procedures are granted.
- These zones also facilitate foreign direct investment (FDI), enabling international firms to set up joint ventures or wholly owned manufacturing bases easily.

Belt and Road Initiative (BRI)

- Through the BRI, China has expanded its **logistics and trade links**, particularly into Southeast Asia, Europe, and Africa, supporting the global reach of Chinese PCB exporters.
- 7. What other trends should the Commission be tracking on this topic?
 - **Tariffs.** Tariffs should be applied selectively When the policies make foreign sourced products more expensive and the supply chain for PCB inputs has been globalized, it increases the cost for all inputs required to produce PCBs in the U.S. What is needed is government investment that creates a demand signal and brings private investment to the table.
 - Discovery of "phone home" functionality in infrastructure systems. For example, in recent reporting from <u>Reuters</u> revealed that rogue communication devices were found in Chinese solar power inverters. A similar capability was found in the <u>electronics built into cranes</u> unloading cargo in one of our largest ports. A "phone home" functionality could provide a way for the originators to control not just solar panels, but also air traffic control systems, cellular communication, banking, and medical systems. Taking steps to address this vulnerability is a national security and economic imperative. We should not wait until the first major attack occurs to get serious about this. It will take both increased manufacturing as well as rigorous cybersecurity to protect the U.S. from what could be a catastrophic disruption across the country.
- 8. The Commission is mandated to make policy recommendations to Congress based on its hearings and other research. What recommendations not already covered in answer to questions above for legislative or administrative action would you make in this area?
 - We need to reinvigorate the American PCB and substrate industry through strategic government investment that will in turn draw private investors off the sideline. The CHIPS Act drove hundreds of billions of private investment in semiconductors and a similar approach should be taken for PCBs, and we anticipate a similar private investment outcome
 - An important first step to set things in motion is **passing the reintroduced bipartisan Protecting Printed Circuit Boards and Substrates (PCBS) Act.** This legislation proposes \$3 billion in funding for factory construction, workforce development, and research and development. It also includes a 25 percent tax credit for purchasers of American-made PCBs and substrates, incentivizing domestic production and consumption.

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- Expanding the definition of national security components. PCBs are in every national security and critical infrastructure system. At the moment defense articles are strictly controlled. The PCBs destined for defense systems are almost entirely made in the U.S. Despite the fact we are currently meeting demand from domestic sources, there is little capacity to scale up in times of crisis. Finally, we have only scratched the surface of the risk with critical infrastructure and Congress and the government agencies should work together to prevent what could be a catastrophic failure of systems we depend on for daily life in our country. We strongly encourage the Commission to recommend an outright ban of Chinese PCBs in US Government procured dual-use and commercial technology.
- Ensuring U.S. dominance on emerging critical national security programs and objectives. Artificial Intelligence (AI) leadership is defined as a critical objective by the U.S. The processing of AI is facilitated by high-end microelectronics (such as NVDIA chips) that are mounted on substrates and assembled on PCBs that are installed the servers deployed in data centers. The PCB types required (HDI and uHDI) are only produced by a handful of PCB manufacturers in the U.S. and not at the scale that will be required to build-out our AI superiority. HDI PCB fabrication is organically capacity erosive due to the sequential build-up nature of the technology and uHDI is currently deployed only for small scale requirements. HDI and uHDI PCBs have been identified as supply chain high level threat vectors by Commerce. The Golden Dome initiative is comprised of systems such as hypersonic and ballistic missile tracking space sensors, satellite layers, missiles and command and control systems. All these system architectures are reliant on military grade PCBs to function. In the case of missiles, this requires oversized panel manufacturing of PCBs that is only achievable in a few of U.S. fabricator locations.