Bureau of Industry and Security
Department of Commerce
Request for Public Comments
"Risks in the Information and Communications Technology Supply Chain"
Docket #: 210910-0181
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Submitted by: IPC and USPAE

Introduction

On behalf of our more than 1,500 U.S. member companies in the electronics manufacturing industry, IPC and the U.S. Partnership for Assured Electronics (USPAE) support the Administration's focus on addressing risks to America's strategic supply chains pursuant to President Biden's Executive Order (EO) 14017, *America's Supply Chains*.

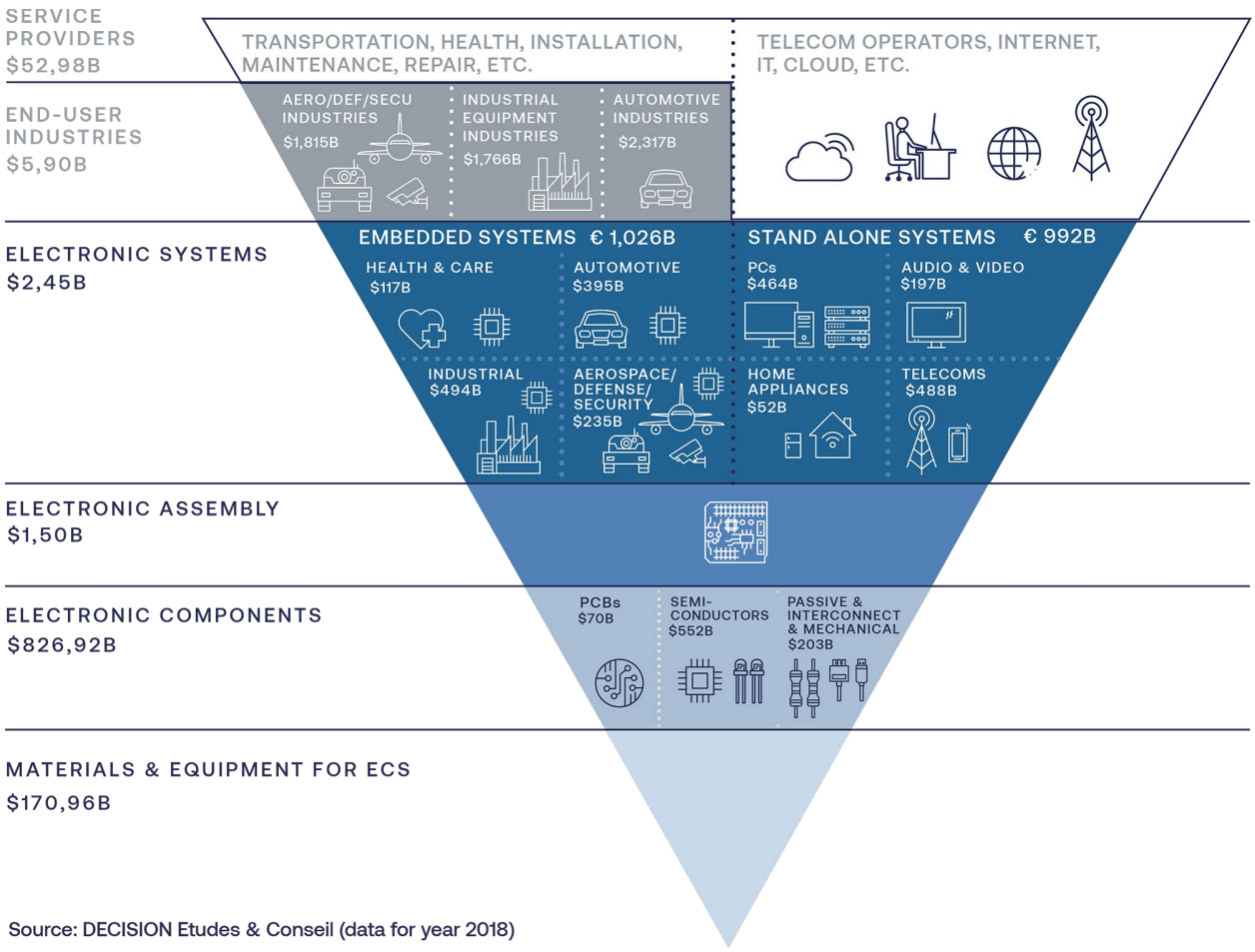
IPC is a global industry association based in Bannockburn, Illinois. We help manufacturers of all sizes build electronics better through technical standards, workforce programs, research, and advocacy. USPAE is an industry association working to ensure that the U.S. Government has access to resilient and trusted electronics supply chains. Together, our members support more than 5 million U.S. jobs and drive more than $700 billion in U.S. GDP. They span all segments of electronics manufacturing, including designers, printed circuit board (PCB) manufacturers, contract and assembly companies, suppliers, and original equipment manufacturers (OEMs) in aerospace, defense, medical, automotive, and other industrial sectors reliant on electronics.

It is no overstatement to say that our lives depend on electronics. A vertical industry in its own right, electronics manufacturing also is a horizontal industry cutting across almost every sector of the economy, from telecommunications to information technology, medical equipment, safety and security systems, transportation, retail, and more.

Advancements in electronics have been especially critical to the development of the information and communications technology (ICT) industry, which has reshaped the nature of work, social connection, and personal enrichment in the modern world. Promoting the resiliency and security of an innovative ICT industry begins with bolstering the ecosystem for electronics manufacturing. As we will explain here, the electronics ecosystem in the United States is far too weak as the result of global economic trends and a lack of attention by the U.S. Government for more than two decades.

Now, a confluence of global events is forcing governments around the world to rethink supply chain resiliency and security, as well as the importance of nurturing technological innovation. As the U.S. Government examines risks in the U.S. ICT supply chain, we encourage a holistic analysis that includes the electronics manufacturing ecosystem upon which the ICT industry relies. This ecosystem includes the manufacturers of active and passive components (like semiconductor chips), but also those companies engaged in PCB fabrication and assembly, without which semiconductors cannot function.

Global Electronics Value Chain



Source: DECISION Etudes & Conseil (data for year 2018)

Electronics Ecosystem

The last 25 years have been a turbulent period for U.S. electronics manufacturers, marked by significant contraction and financial instability. By several estimates, the top 100 electronics companies in the world produced more than $2.4 trillion worth of electronic equipment in 2020. Although many of these companies are headquartered in the United States, the U.S. share of global electronics manufacturing has shrunk from about 30 percent to less than 5 percent over the last 25 years. Manufacturers in Asia now produce more than 70 percent of all electronics manufactured globally.

Despite the outsized importance of electronics in the modern economy, the United States has failed to nurture it. Moreover, the U.S. Government's current focus on strategic supply chains does not fully appreciate that electronics manufacturing is a complex ecosystem. Like any ecosystem, each segment must be robust and resilient for the entire ecosystem to thrive. The electronics manufacturing ecosystem is the platform upon which innovation is made possible, and supply chain security and resiliency are assured.

The key segments that make up the electronics manufacturing ecosystem are shown in the diagram above and include:

- **Original Equipment Manufacturers (OEMs)** manufacture finished products, although the business model is increasingly focused on product design, innovation, and development, with actual manufacturing outsourced to others.
- **Electronics Manufacturing Services (EMS)** companies mount, connect, and assemble various electronic components onto PCBs or integrated circuit (IC) modules. EMS companies offer an array of value-add services, including design, supply chain management, packaging, final system assembly, and fulfillment/distribution.
- **Electronic Component Manufacturers** produce the hardware components that are placed on PCBs. Today's electronics can contain thousands of components on a single board.
- **Printed Circuit Board (PCB) Manufacturers** make the boards that mechanically support and electrically interconnect electronic components using conductive traces, pads, plated holes (vias), and other features. PCBs are made of one or more layers of metals that are laminated onto and/or in between layers of non-conductive substrates.
- **Mechanical Component Suppliers** create the mechanical hardware that is needed for final finished electronic products, including heat sinks, insulators, bezzles, frames, etc.
- **Wire Harness Manufacturers** make the electrical cables and wiring systems that carry power and electronic signals between two or more electronic systems.
- **Equipment Manufacturers** produce the machines needed to manufacture wire harnesses, electronic components, and PCBs, such as lithographic equipment, deposition machines, etching and cleaning machines, process control machines, etc.
- **Raw Materials Producers** provide the materials, including rare earth minerals, needed to manufacture electronic components and PCBs.

From Silicon to Systems

Considerable attention has been given to the current semiconductor shortage and the global race for next-generation innovation. This attention is entirely justifiable given the role of semiconductor chips in providing processing power and memory. Ever more powerful semiconductor chips are critical to the ongoing innovation in ICT.

And yet, these chips do not function on their own. They must be attached to substrates and then packaged and interconnected with other pieces of hardware and software to deliver their value.

Understanding the ecosystem for advanced packaging and PCB assembly has never been more important given the inability of chip fabricators to keep pace with Moore's Law. In the mid-1960s, Intel founder Gordon Moore predicted that the number of transistors that fit onto an IC could double about every two years, allowing the production of ever more powerful chips with greater cost efficiencies. As an empirical claim, Moore's Law held true for more than half a century. But today, silicon chip advancements have slowed, along with the associated economic benefits. Now, semiconductor

designers are increasingly relying on advancements in the packaging of silicon chips to achieve the greater functionality and efficiencies that they previously realized through silicon scaling.

Advancements in packaging today are being driven by "heterogenous integration," which offers an alternative technological path to achieving the promise of Moore's Law. Most simply, heterogeneous integration is the process of combining multiple chiplets (logic or memory) into a single package. Heterogeneous integration is leading to smaller, faster, 3D-stacked, multi-functional silicon logic and memory devices.

Advancements in semiconductor packaging have direct impacts on PCB technology and fabrication. The more sophisticated IC packages become, the more complex PCB designs must become. Final system-level assembly by EMS companies or original design manufacturers (ODM) is where the product comes to life; this is where electronics are assembled, powered on, burned-in, firmware/software loaded, and final system tests are performed. Both PCB and EMS/ODM providers play a critical role in final system delivery and availability. A healthy, capable assembly ecosystem is needed to bring a wide variety of technologies together to manufacture finished products. Any disruptions or bottlenecks within this end-to-end ecosystem can lead to delays in new product introduction. Therefore, it takes all the elements within the supply chain—from silicon to systems—to successfully produce electronic hardware products and to meet customer demands of the ICT industry and other industries.

Case Study: Printed Circuit Boards

The loss of U.S. leadership in PCB fabrication is emblematic of the nation's shortsighted approach to electronics manufacturing. Prior to the Asian shift of 2000-2001, just over $11 billion worth of PCBs were produced in the United States. Along with Japan, the United States enjoyed a leadership position in this critical and enabling technology. Today, just over $3.5 billion worth of PCBs are produced in the United States. The decline was due, in part, to a make-or-buy decision by OEMs, which, even as late as the mid-1990s, produced their own captive interconnects to support their hardware. Many OEMs shuttered their PCB fabrication facilities in favor of partnering with merchant fabricators. The offshoring of PCB fabrication began, and China became the leading source of PCBs, a position that it continues to occupy today.

Multiple government and industry studies over the last 20 years have sounded alarms about the implications of a declining U.S. PCB industry, but little action was taken to address these concerns. Today, the most advanced technologies related to high-end PCB fabrication are no longer being developed in the United States. When the PCB industry shifted to Asia, much of the research and development (R&D) capability went along with it. Consider High Density Interconnect (HDI) technology, which was invented in the United States. It is a great enabler as it allows faster signal speeds, smaller form factors, and lower overall system costs. The majority of HDI production today resides in Asia, and we know from experience that manufacturing and technology clusters, i.e., providers of specialized equipment, materials, chemistry, and assembly, will follow production.

Disruptive Technologies Driving Radical Change in Electronics Manufacturing

Although the loss of U.S. manufacturing leadership is lamentable, this is an exciting time to be in electronics. Electronics manufacturing is on the cusp of radical change, driven by disruptive, emerging

technologies and processes and powered by skilled workers. Digital technologies and disruptive tools such as artificial intelligence, automation, 3D printing, robotics, and the industrial "internet of things" are transforming manufacturing and will demand more from PCBs.

Disruptive and emerging technologies are enabling a new era of faster, more efficient, precise, and nimble manufacturing as industry migrates to the factory of the future. These changes provide a pathway for a revitalized U.S. electronics manufacturing industry. The nations that lead the way on the factory of the future will be those with strong fiscal and tax policy incentives for investment in R&D, in capital infrastructure, and in workforce upskilling. Government policies will play a major role in whether U.S. electronics manufacturers will keep up with the times or be phased out.

In the electronics manufacturing industry, European companies and institutions are leading the way on the factory of the future, and those in the Asia-Pacific region are gaining momentum. IPC estimates that companies in the United States are already up to 10 years behind in developing the leading-edge factories of the future. The United States needs to ramp up its support for a transition to the factory of the future and take advantage of the "leapfrog" opportunity this transition offers.

Electronics manufacturing is a notoriously thin-margin business, making it difficult to invest in R&D or upgrade costly manufacturing equipment. And yet, such upgrades will be necessary to perform the sophisticated work expected of U.S. manufacturers by their customers, including the Department of Defense (DoD). These equipment upgrades are also imperative to achieving the capabilities, quality standards, and cost-efficiencies necessary to compete in the global economy.

Risks to National Security

Advanced electronics are at the heart of most defense and security systems and many other kinds of critical infrastructure. However, as electronics have become more and more crucial in these vital systems, supply chain disruptions have become a greater concern. The U.S. military is still the most advanced in the world, and U.S. companies are still the top innovators globally. But any constraints or compromises involving any electronics system components—even tiny, inexpensive ones—can bring entire systems to a halt.

The long-running erosion of the U.S. electronics ecosystem and the recent supply chain disruptions have compromised domestic capabilities to manufacture cutting-edge technologies. This loss not only makes America less competitive in global commerce; it also undermines military capabilities and readiness, creating unnecessary risks to U.S. national security.

We encourage federal support of "trusted supplier" programs in the domestic and international supply chains for critical sectors. Defining a community of trusted suppliers will allow the U.S. Government to measure and support the growth of a robust defense industrial base. In that spirit, we urge the U.S. Government to establish metrics for defense electronics industrial base resiliency, with capacity, capabilities, security, and geographic diversity as key factors.

Recommendations

It is important for policymakers to have a complete understanding of electronics manufacturing as our nation grapples with challenges in the ICT supply chain. The United States must continue to strengthen its leadership in all areas of the electronics ecosystem, and it must do so by investing in R&D and establishing a federal strategy for electronics manufacturing as it addresses America's supply chains. Specifically, IPC and USPAE urge the following:

- **Create a new national manufacturing institute specifically focused on advanced electronic interconnection.** This proposed institute could be joined with a newly established institute for semiconductor advanced packaging as electronic interconnection is central to the innovation taking place in advanced packaging. Creating an institute focused on electronic interconnects would help U.S. PCB and assembly companies develop and implement advanced manufacturing technologies with the goal of establishing world-class, cost-competitive electronics manufacturing in the United States.

- **Work with Congress to establish tax credits to support the industry's migration to factories of the future.** Specifically, tax policy needs to encourage the purchase of next-generation equipment that increases production, reduces costs, and supports achievement of other strategic goals, including energy efficiency, a skilled workforce, and supply chain transparency.

- **Establish a Defense Production Act Title III Program** focused on commercializing developments in PCB manufacturing and assembly, as well as the materials and capital equipment upon which they rely.

- **Fully implement Section 841 of the FY2021 National Defense Authorization Act (NDAA),** which aims to bolster the security and resiliency of the U.S. defense electronics supply chain. Section 841 extended "trusted supplier" requirements to PCBs and printed circuit board assemblies (PCBAs) and called for a Federally Funded Research and Development Center (FFRDC) study on risks associated with commercial-off-the-shelf (COTS) electronics procured for DoD use.

- **Establish a trusted supplier program for PCBs and PCBAs that are integrated into sensitive government ICT equipment.** IPC has worked with DoD to establish IPC-1791, an industry standard for *Trusted Electronic Designer, Fabricator and Assembler Requirements*, to ensure trusted sourcing for critical military and national security applications. IPC-1791 outlines requirements, policies, and procedures for PCB design, fabrication, and assembly organizations to become trusted sources for markets requiring high levels of confidence in the integrity of delivered products, such as military and aerospace.

  Federal agencies that procure ICT for sensitive equipment should consider requiring vendors to leverage IPC-1791 to ensure the reliability and security of their electronics. IPC-1791 is a valuable tool to certify trusted electronics manufacturers, but it also offers the opportunity to define a community of suppliers around which the health can be measured and promoted.

We appreciate the opportunity to provide feedback on risks in the ICT supply chain and look forward to partnering with the Department of Commerce as it conducts its supply chain review. To initiate this, IPC offers to host a series of meetings or workshops that brings together industry, academia, and government to identify solutions that will improve America's supply chain challenges. Thank you for your consideration of these comments.