U.S. Department of Commerce
Bureau of Industry and Security
Office of Technology Evaluation

U.S. BARE PRINTED CIRCUIT BOARD INDUSTRY ASSESSMENT:

For further information about this report, contact:
Mark Crawford, Senior Trade & Industry Analyst, (202) 482-8239, Mark.Crawford@bis.doc.gov
Stamen Borisson, Trade & Industry Analyst, (202) 482-3893, Stamen.Borisson@bis.doc.gov

Brad Botwin
Director, Industrial Studies
Office of Technology Evaluation
Brad.Botwin@bis.doc.gov
Phone: (202) 482-4060

For more information about the Office of Technology Evaluation, Industrial Base Studies and Section 232 Investigations, please visit:

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
# Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Chapter 1: Respondent Profile and Organization Information</td>
<td>10</td>
</tr>
<tr>
<td>Chapter 2: Customers and Competitors</td>
<td>27</td>
</tr>
<tr>
<td>Chapter 3: Participation in U.S. Government Programs and U.S. Government Interactions</td>
<td>43</td>
</tr>
<tr>
<td>Chapter 4: Bare PCB Manufacturing</td>
<td>63</td>
</tr>
<tr>
<td>Chapter 5: Materials and Equipment</td>
<td>114</td>
</tr>
<tr>
<td>Chapter 6: Sales</td>
<td>140</td>
</tr>
<tr>
<td>Chapter 7: Financials</td>
<td>157</td>
</tr>
<tr>
<td>Chapter 8: Research and Development (R&amp;D) and Capital Expenditures (CAPEX)</td>
<td>168</td>
</tr>
<tr>
<td>Chapter 9: Employment</td>
<td>194</td>
</tr>
<tr>
<td>Chapter 10: Competitive Factors</td>
<td>205</td>
</tr>
<tr>
<td>Chapter 11: Cyber Security</td>
<td>229</td>
</tr>
<tr>
<td>Chapter 12: Challenges and Outreach</td>
<td>240</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Bureau of Industry and Security (BIS)

• BIS Mission:

➢ Advance U.S. national security, foreign policy, and economic objectives by ensuring an effective export control and treaty compliance system and promoting continued U.S. strategic technology leadership

➢ BIS also develops and implements policies and programs that ensure a strong, technologically superior defense industrial base

• The Office of Technology Evaluation (OTE) is the focal point within BIS for analyzing the capabilities of the U.S. industrial base to support the national defense
BIS Industry Surveys & Assessments

Background and Authority

• Under Section 705 of the Defense Production Act of 1950 and Executive Order 13603, ability to survey and assess:
  ➢ Economic health and competitiveness
  ➢ Defense capabilities and readiness

• Mandatory data collection authority under Section 705 of the DPA with data exempt from Freedom of Information Act (FOIA) requests

• Enable industry and government agencies to:
  ➢ Share data and collaborate in order to ensure a healthy and competitive industrial base
  ➢ Monitor trends and benchmark industry performance
  ➢ Raise awareness of diminishing manufacturing and technological capabilities
Bare Printed Circuit Board Assessment Sponsor

BIS/OTE, in coordination with the U.S. Department of the Navy, Naval Surface Warfare Center, Crane Division (NSWC Crane) conducted an assessment of the U.S. Bare Printed Circuit Board (PCB) industrial base.
Project Background

• BIS/OTE entered in an agreement with the Naval Surface Warfare Center, Crane Division of Naval Sea Systems Command (NAVSEA) in December 2014 to perform an industrial assessment of the U.S. Bare Printed Circuit Board industrial base.

  ➢ NSWC Crane is the DoD Executive Agent (EA) for printed circuit board technology.

  ➢ Provides acquisition engineering, in-service, engineering and technical support for sensors, electronics, electronic warfare and special warfare weapons.

  ➢ NSWC Crane also works to apply component and system-level product and industrial engineering to surface sensors, strategic systems, special warfare devices and electronic warfare/information operations systems.
Assessment Objectives

• To combine NSWC Crane’s technical capabilities with OTE’s survey expertise to assess the health and competitiveness of U.S. Bare Printed Circuit Board manufacturers and their supply chain, leverage industry best practices where applicable, and coordinate development and communication of issues across the DoD community.

• The following issues were examined, covering the period from 2012 to 2015:

  ➢ Economic health, competitiveness, and financial performance
  ➢ Production capabilities and constraints
  ➢ Participation in U.S. Government programs
  ➢ Supply chain network, customers and suppliers
  ➢ Foreign competition, sourcing, and dependencies
  ➢ Sales and exports
  ➢ Investment and R&D
  ➢ Employment and core competencies
  ➢ Cyber security and counterfeits
  ➢ Other topics as needed
BIS Survey Development

- BIS undertook a number of steps to better understand the industry and to design a survey instrument that captured the programmatic needs of NSWC Crane.

- Specifically, BIS held discussions with NSWC Crane, industry groups and government organizations to define the scope of technical information beneficial to the objectives of the assessment.

- Conducted site visits in order to obtain first hand knowledge of the operational and business practices particular to the Bare PCB industry.

- Additional information was gathered via field testing of the survey instrument with industry, government, and university experts via telephone and email.
BIS Survey Design and Data Collection

• Survey questions were designed to support the assessment objectives and capture and snapshot in time (four years) of trends in the various topics examined as part of the assessment.

• BIS tested a draft survey for accuracy and usability with a number of representatives from industry and government.

• The aggregate data provides a valuable instrument for performing analysis and informing industry and government stakeholders of industry trends and challenges.

• The data also assists BIS partner agencies in identifying issues related to U.S. Bare Printed Circuit Board manufacturers and their supply chain, and coordinating development and communication of those issues across the DoD community.

• Data collected via the survey instrument was supplemented with information from discussions with industry and government experts, site visits, and participation in industry conferences.
CHAPTER 1: RESPONDENT PROFILE AND ORGANIZATION INFORMATION

- CATEGORIZATION OF RESPONDENTS
- MANUFACTURING CAPABILITIES
- LOCATIONS OF U.S. BARE PCB MANUFACTURING FACILITIES
- COMMERCIAL AND DEFENSE MARKET SEGMENTS PARTICIPATION

- 5 large companies operate 18 facilities in the U.S.

- Total 2015 Bare Printed Circuit Board Sales of $2 Billion

- BIS categorized respondent facilities and companies as large, medium or small. Organization size was established based on the 2015 sales values reported from bare printed circuit boards manufactured in the U.S.
  - Large – more than $40M in 2015 bare PCB sales
  - Medium – between $10M and $40M in 2015 bare PCB sales
  - Small – less than $10M in 2015 bare PCB sales
All 202 BIS survey respondent facilities reported bare PCB manufacturing capabilities. Sixty-one facilities reported bare PCB design capabilities and 61 facilities reported bare PCB assembly capabilities.

Manufacturing Services – All U.S. Bare PCB Facilities (2015)

- 202 bare PCB manufacturing facilities
- 61 bare PCB design facilities
- 61 bare PCB assembly facilities
- 145 facilities reported some level of bare PCB production and sales attributable to defense end use:
  - 10 Large
  - 43 Medium
  - 92 Small
- 47 defense end use facilities reported bare PCB design capabilities.
- 48 defense end use facilities reported bare PCB assembly capabilities.

Source: U.S. Department of Commerce, Bureau of Industry and Security

Respondents: 202
Survey Respondent Profile/Organization Information
Facility Size and Bare PCB Manufacturing Capabilities

Manufacturing Capabilities – Types of Boards (2015)

- 195 facilities reported **rigid** bare PCB manufacturing capability
  - 10 Large
  - 44 Medium
  - 141 Small

- 112 facilities reported **flex** bare PCB manufacturing capability
  - 6 Large
  - 24 Medium
  - 82 Small

- 85 facilities reported **rigid-flex** bare PCB manufacturing capability
  - 5 Large
  - 21 Medium
  - 59 Small

Q5a,A

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017

202 respondents
Survey Respondent Profile/Organization Information
Bare PCB Manufacturing Capabilities With Defense End-Users

Manufacturing Capabilities – Types of Boards
Facilities with Defense End Use Applications (2015)

- 139 facilities reported rigid bare PCB manufacturing capability
  - 10 Large
  - 41 Medium
  - 88 Small

- 112 facilities reported flex bare PCB manufacturing capability
  - 6 Large
  - 24 Medium
  - 55 Small

- 85 facilities reported rigid-flex bare PCB manufacturing capability
  - 5 Large
  - 21 Medium
  - 47 Small

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Survey Respondent Profile/Organization Information

Locations of U.S. Bare PCB Manufacturing Facilities (2015)

- Nine Companies Operate More Than One U.S. Bare PCB Facility

- California: Large >$40M
- Illinois: Medium $10M-$40M
- Minnesota: Small <$10M
- Texas: Medium $10M-$40M
- Wisconsin: Small <$10M
- New York: Medium $10M-$40M
- Pennsylvania: Small <$10M
- Colorado: Small <$10M
- New Jersey: Small <$10M
- Utah: Small <$10M
- New Hampshire: Small <$10M
- Arizona: Small <$10M
- Ohio: Small <$10M
- Others: Small <$10M

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Survey Respondent Profile/Organization Information

Locations of U.S. Bare PCB Manufacturing Facilities (2015)

Q1a,A

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017

<table>
<thead>
<tr>
<th>States</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>70</td>
</tr>
<tr>
<td>IL</td>
<td>29</td>
</tr>
<tr>
<td>MN</td>
<td>12</td>
</tr>
<tr>
<td>TX</td>
<td>11</td>
</tr>
<tr>
<td>NY</td>
<td>8</td>
</tr>
<tr>
<td>WI</td>
<td>8</td>
</tr>
<tr>
<td>PA</td>
<td>7</td>
</tr>
<tr>
<td>NH</td>
<td>5</td>
</tr>
<tr>
<td>UT</td>
<td>5</td>
</tr>
<tr>
<td>NJ</td>
<td>5</td>
</tr>
<tr>
<td>CO</td>
<td>5</td>
</tr>
</tbody>
</table>

202 respondents
Survey Respondent Profile/Organization Information
U.S. Bare PCB Facilities: Publicly Traded vs. Privately Held

Number of U.S. Bare PCB Facilities Belonging to Publicly Traded vs. Privately Held Organizations (2015)

- Privately Held, 180, 89%
- Publicly Traded, 22, 11%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Survey Respondent Profile/Organization Information
U.S. Bare PCB Facilities: Types of Business Ownership

Number of Facilities That Qualify as Any of The Following Types of Business (2015)

- Small business enterprise (as defined by the SBA): 142
- 8(a) Firm (as defined by the SBA): 16
- Historically underutilized business zone (HUBZone): 9
- Minority-owned business: 62
- Woman-owned business: 22
- Veteran-owned or service-disabled veteran-owned business: 10

*Small Business Administration (SBA)
**A facility can qualify as more than one type of business.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017

Q1b,C

202 respondents
Survey Respondent Profile/Organization Information

Percent of Bare PCB Sales with Commercial End Use (2015)

Estimated percentage of bare circuit board sales attributable to COMMERCIAL end use by facility

- 98% of facilities reported bare PCB sales attributable to commercial end use

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment - 2017
Survey Respondent Profile/Organization Information
Commercial End Use Market Segments (2015)

U.S. Bare PCB Facilities – Commercial Market Segments Participation

- Industrial Electronics: 159 facilities
- Communications: 157 facilities
- Medical/Healthcare: 142 facilities
- Computers/Business Equipment: 130 facilities
- Aerospace: 129 facilities
- Consumer Goods: 124 facilities
- Automotive: 92 facilities
- Marine (surface and underwater): 71 facilities
- Space: 64 facilities
- Other: 40 facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Survey Respondent Profile/Organization Information
Bare PCB Sales Percentages for Specific Commercial Uses

U.S. PCB Facilities – Average Estimated % of Bare PCB Sales

<table>
<thead>
<tr>
<th>Commercial Market Segment</th>
<th>Percent of Bare PCB Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Electronics</td>
<td>23%</td>
</tr>
<tr>
<td>Communications</td>
<td>13%</td>
</tr>
<tr>
<td>Medical/Healthcare</td>
<td>11%</td>
</tr>
<tr>
<td>Computers/Business Equipment</td>
<td>11%</td>
</tr>
<tr>
<td>Aerospace</td>
<td>11%</td>
</tr>
<tr>
<td>Consumer Goods</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
</tr>
<tr>
<td>Automotive</td>
<td>4%</td>
</tr>
<tr>
<td>Space</td>
<td>2%</td>
</tr>
<tr>
<td>Marine (surface and underwater)</td>
<td>2%</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

Q1c,B

202 respondents
Survey Respondent Profile/Organization Information

Percent of Bare PCB Sales Linked to Defense End Use (2015)

Estimated percentage of bare circuit board sales attributable to DEFENSE end use by facility

- 145 facilities (72%) reported defense end use
- 58 facilities consider themselves dependent on USG programs for their continued viability

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q1c,A

202 respondents
Respondent Profile/Organization Information

U.S. Bare PCB Facilities – Defense Market Segments Participation

- Electronics: 106 facilities
- Aerospace: 99 facilities
- Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR): 92 facilities
- Missiles: 72 facilities
- Marine (Surface and Underwater): 64 facilities
- Space: 62 facilities
- Ground Vehicles: 53 facilities
- Other: 26 facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security

145 respondents
Respondent Profile/Organization Information

Bare PCB Sales Percentages for Specific Defense Uses (2015)

U.S. PCB Facilities – Average Estimated % of Bare PCB Sales

- Aerospace: 19%
- Electronics: 15%
- Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR): 9%
- Missiles: 8%
- Other: 4%
- Space: 4%
- Ground Vehicles: 3%
- Marine (Surface and Underwater): 3%

Source: U.S. Department of Commerce, Bureau of Industry and Security

145 respondents
A number of respondents reported having incomplete or no information on the end uses of the products they make – defense or commercial

- “Most customers are contract manufacturers and we are not informed of product's end use.”
- “We don't have any systematic way of tracking the end use of the boards we sell. They are made to customer print. We are not told what they are used for.”
- “It is unknown exactly where our PCBs end up when they are shipped to our defense subcontractor customers. This information is not shared with us by our customers.”
- “All of the USG and defense work we do is done indirectly through our customers. We do not have any jobs that we do directly with the DOD or USG.”
- “Defense end use throughout this survey is pure speculation. We very rarely (if ever) know what the end use is.”
- “We do not know end use. This is a estimate. IPC-6012A and MIL-PRF-55110 is only 3% of business.”
Mergers and Acquisitions (M&As)
28 reported mergers and acquisitions since 2012
- 25 with U.S. companies
- 2 with Chinese companies
- 1 with a U.K. company

Joint Ventures (JVs)
8 joint ventures reported
- No data on country of JV entities
- “Other” JV objectives included co-production and broker partnership

Primary Objective

<table>
<thead>
<tr>
<th>Objective</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broaden customer base</td>
<td>10</td>
</tr>
<tr>
<td>Develop new capabilities</td>
<td>7</td>
</tr>
<tr>
<td>Vertical integration</td>
<td>4</td>
</tr>
<tr>
<td>Other objective/purpose (Explain)</td>
<td>4</td>
</tr>
<tr>
<td>Reduce Costs</td>
<td>1</td>
</tr>
<tr>
<td>Bankruptcy restructuring/litigation</td>
<td>1</td>
</tr>
<tr>
<td>Access to intellectual property</td>
<td>1</td>
</tr>
</tbody>
</table>

Other objective/purpose

<table>
<thead>
<tr>
<th>Objective</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product improvements</td>
<td>2</td>
</tr>
<tr>
<td>Shared/improved technology or skills</td>
<td>1</td>
</tr>
<tr>
<td>Improved access to U.S. markets</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
CHAPTER 2: CUSTOMERS AND COMPETITORS

• TOP CUSTOMERS
• FACTORS IN REJECTING BUSINESS OPPORTUNITIES
• LEADING COMPETITORS
• COMPETITIVE ADVANTAGE: U.S. VS NON-U.S.
Customers & Competitors
U.S.-Based Bare Printed Circuit Board Customers

Respondents were asked to identify their top 5 U.S. direct customers by sales for the period 2012 to 2015, indicating the type of customer, the primary end use, and the customer location.

- **915 U.S customers were identified**
  - Over two-thirds (68 percent) were commercial customers, with almost one-quarter (24 percent) Government Defense customers.
  - ‘Electronics’ was the leading primary end use with 29 percent of responses.
  - California was the number one state for top U.S. bare PCB customers with 26 percent of responses.

- **273 Non-U.S customers were identified**
  - 82 percent were commercial customers with Government Defense accounting for 10 percent of responses.
  - ‘Electronics’ was the leading primary end use with 30 percent of responses.
  - Canada, Malaysia, and China were the top reported countries for non-U.S. bare PCB customers with approximately 14 percent of responses each.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Customers & Competitors
U.S.-Based Bare Printed Circuit Board Customers (2012-2015)

Types of U.S. Customers (915 total)

- Commercial, 626, 68%
- Government Defense, 222, 24%
- Government Non-Defense, 33, 4%
- Other, 29, 3%
- University/Non-Profit, 5, 1%

202 respondents
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Customers & Competitors
U.S.- Based Customers By Primary End Use (2012-2015)

Primary End Uses of Bare Printed Circuit Boards – U.S. Customers

- Electronics: 267
- Aerospace: 124
- Industrial Electronics: 106
- Communications: 92
- Other: 68
- Medical/Healthcare: 60
- Consumer Goods: 49
- Computers/Business Equipment: 41
- Missiles: 40
- Automotive: 22
- Ground Vehicles: 10
- Space: 8
- Marine (Surface and Underwater): 8
- C4ISR: 6
- No Response: 14

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Customers & Competitors
U.S.-Based Customers By State (2012-2015)

Geographic Locations of Bare Printed Circuit Board Customers in U.S.

- California: 236 customers
- Illinois: 50 customers
- Texas: 49 customers
- New York: 49 customers
- Florida: 41 customers
- Minnesota: 39 customers
- Wisconsin: 37 customers
- Massachusetts: 36 customers
- Pennsylvania: 33 customers
- Ohio: 30 customers
- Other (34 States): 300 customers
- No response: 15 customers

Source: U.S. Department of Commerce, Bureau of Industry and Security
Customers & Competitors
Non-U.S.-Based Bare Printed Circuit Board Customers (2012-2015)

Types of Non-U.S. Customers (273 total)

- Commercial, 223, 82%
- Government Defense, 27, 10%
- Government Non-Defense, 6, 2%
- Other, 17, 6%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Customers & Competitors
Non-U.S. Based Customers By Primary End Use (2012-2015)

Primary End Uses for Bare Printed Circuit Boards – Non-U.S. Customers

- Electronics: 82
- Aerospace: 39
- Medical/Healthcare: 35
- Industrial Electronics: 30
- Communications: 27
- Computers/Business Equipment: 21
- Automotive: 9
- Consumer Goods: 8
- Missiles: 7
- Space: 2
- Marine (Surface and Underwater): 1
- No Response: 3

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Customers & Competitors
Non-U.S. Based Customers By Country (2012-2015)

Geographic Locations of Bare Printed Circuit Board Non-U.S. Customers

- Canada: 40 customers
- Malaysia: 38 customers
- China: 38 customers
- United Kingdom: 24 customers
- Germany: 14 customers
- Singapore: 13 customers
- Mexico: 11 customers
- Italy: 7 customers
- Israel: 7 customers
- Other (28 countries): 78 customers
- No Response: 3 customers

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Customers & Competitors
Rejected Business Opportunities (2012-2015)

Respondents were asked whether they has rejected any business opportunities due to any of a number of factors. The leading factor for rejecting business opportunities in the responses was ‘Complexity of Job.’ Comments received included:

- “Do not posses manufacturing capabilities to produce latest technology complex circuit boards.”
- “Some board requirements may be beyond our capabilities.”
- “Too high layer count, too tight lines/spaces, exotic materials, etc.”
- “PCB layer count beyond our capabilities.”
- “Need more equipment.”
- “Design at RFQ was beyond process capabilities.”

Other top factors included ‘Customer Credit Rating’ and ‘Insufficient Dollar Value of Job.’ Respondents reported that they require minimum production and order values to justify set up and production costs. They also reported facing additional pricing pressure as potential customers are asking for pricing quotes matching bare PCBs produced offshore.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Customers & Competitors
Rejected Customer Business Opportunities (2012-2015)

Factors for Rejecting Business Opportunities

- Complexity of Job: 127
- Customer Credit Rating: 72
- Insufficient Dollar Value of Job: 69
- Insufficient Dollar Value of Recurring Business Opportunity: 36
- Insufficient Order Frequency: 15
- Other Criteria: 12
- Additional Work Not Needed: 12
- Circuit Board Panel Production Run Too Small: 11

Other criteria included:
Production run too large, rapid turn around request, lack of credentials, raw material shortage, panel size.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
## Customers & Competitors

### Factors for Rejecting Business Opportunities

<table>
<thead>
<tr>
<th>Factor for Rejecting Business Opportunity</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| **Complexity of Job** | “Design at RFQ was beyond process capabilities.”  
  “Do not possess manufacturing capabilities to produce latest technology complex circuit boards.”  
  “Need more equipment.”  
  “PCB layer count beyond our capabilities.”  
  “Some board requirements may be beyond our capabilities.”  
  “Too high layer count, too tight lines/spaces, exotic materials, etc.” |
| **Customer Credit Rating** | “Low profit margins require vigilance of credit.”  
  “Payments upfront, Credit Card or COD is required.”  
  “Select customers have a poor credit report that makes it risky to extend terms.”  
  “Customer with bad history of payments.” |
| **Insufficient Dollar Value of Job** | “Can not afford to do below production cost. They want us to match overseas prices, which is not possible for us.”  
  “Internal policy of minimum order value and annual revenue targets.”  
  “Our minimum lot charge is higher than commercial competition due to MIL documentation.”  
  “Customer requires USA-made at overseas pricing.”  
  “Customers moving business to cheaper labor countries.” |
| **Insufficient Order Frequency** | “Many orders are pure prototype with no future requirements.” |
| **Other Criteria** | “Lacking credentials (e.g., MIL-PRF-31032).”  
  “Panel count could not be produced within customer’s required date.”  
  “We are not a military approved facility.” |
| **Additional Work Not Needed** | “Small amount turned away do to lack of quick-turn capacity.” |
| **Circuit Board Panel Production Run Size** | “Request quantity is too small. It does not meet minimum setup requirements.” |
Customers & Competitors
Competitive Attributes and Geographic Location

Respondents were asked to identify their leading competitors (U.S. and non-U.S.) in the manufacture of bare PCBs, their location, and their primary competitive attribute.

• 236 U.S. Competitors
  ➢ ‘Range of Capabilities’ (40 percent) and ‘Price’ (32 percent) were the leading primary competitive attributes identified.
  ➢ 47 percent of U.S. competitors identified were located in California.

• 253 Non-U.S. competitors
  ➢ ‘Price’ was the dominant primary competitive attribute identified, accounting for 76 percent of responses.
  ➢ China was the leading location for non-U.S. competitors, accounting for 67 percent of responses.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Customers & Competitors
Top U.S. Competitors: Key Factors and Geographic Location

U.S. Competitors
– Primary Competitive Attribute

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Number of Competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of Capabilities</td>
<td>216</td>
</tr>
<tr>
<td>Price</td>
<td>174</td>
</tr>
<tr>
<td>Other</td>
<td>67</td>
</tr>
<tr>
<td>Delivery Time</td>
<td>36</td>
</tr>
<tr>
<td>Financing</td>
<td>16</td>
</tr>
<tr>
<td>Quality</td>
<td>13</td>
</tr>
<tr>
<td>Reliability</td>
<td>8</td>
</tr>
<tr>
<td>Receipt of Government Subsidies</td>
<td>6</td>
</tr>
</tbody>
</table>

U.S. Competitors
– Geographic Location

<table>
<thead>
<tr>
<th>State</th>
<th>Number of Competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>254</td>
</tr>
<tr>
<td>Illinois</td>
<td>62</td>
</tr>
<tr>
<td>Colorado</td>
<td>48</td>
</tr>
<tr>
<td>Minnesota</td>
<td>25</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>17</td>
</tr>
<tr>
<td>Texas</td>
<td>14</td>
</tr>
<tr>
<td>Michigan</td>
<td>14</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>13</td>
</tr>
<tr>
<td>Oregon</td>
<td>12</td>
</tr>
<tr>
<td>Arizona</td>
<td>10</td>
</tr>
<tr>
<td>Other (16 states)</td>
<td>62</td>
</tr>
<tr>
<td>No Response</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Customers & Competitors
Top Non-U.S. Competitors: Key Factors and Geographic Location

Non-U.S. Competitors – Primary Competitive Attribute

- Price: 192
- Range of Capabilities: 24
- Other: 12
- Delivery Time: 7
- Quality: 6
- Receipt of Government Subsidies: 5
- No Response: 7

Non-U.S. Competitors – Geographic Location (20 countries)

- China: 169
- Taiwan: 21
- South Korea (ROK): 9
- Canada: 9
- Switzerland: 8
- Japan: 6
- United States: 5
- Israel: 5
- India: 5
- Mexico: 3
- Other (10 countries): 13

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Customers & Competitors


Respondents were asked to indicate whether bare PCB manufacturers inside the U.S. or outside the U.S. possess the competitive advantage for a list of factors.

According to respondents, U.S. bare PCB manufacturers possess the comparative advantage in:
- Lead Time
- Quality
- Performance

According to respondents, non-U.S. bare PCB manufacturers possess the comparative advantage in various costs which results in lower finished bare PCB prices:
- Labor Costs
- Material Costs
- Equipment Costs
- Environmental Compliance Costs
- Building Space Costs
- R&D Costs

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
### Customers & Competitors

**Competitive Advantage: U.S. vs. non-U.S. (2015)**

<table>
<thead>
<tr>
<th>Category</th>
<th>U.S.</th>
<th>Unknown</th>
<th>None</th>
<th>N/A</th>
<th>Non-U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead Time</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>119</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply of Skilled Workers</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Yield</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced Process Variability</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Requirements</td>
<td>65</td>
<td></td>
<td>38</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Export Controls</td>
<td>36</td>
<td>64</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>R&amp;D Costs</td>
<td>27</td>
<td>66</td>
<td>12</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Environmental Compliance Costs</td>
<td>18</td>
<td>20</td>
<td>7</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Overall Finished Board Price</td>
<td>17</td>
<td>14</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building Space Costs</td>
<td>16</td>
<td>50</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Material Costs</td>
<td>15</td>
<td>22</td>
<td>8</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Equipment Costs</td>
<td>14</td>
<td>42</td>
<td>22</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Reduced Cost</td>
<td>13</td>
<td>24</td>
<td>8</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Labor Costs</td>
<td>12</td>
<td>11</td>
<td>32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Number of Responses**

- **Q3b,A**
- **202 Respondents**

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
CHAPTER 3:
PARTICIPATION IN U.S. GOVERNMENT PROGRAMS AND U.S. GOVERNMENT INTERACTIONS

- U.S. GOVERNMENT AGENCY SUPPORT AND PROGRAM IDENTIFICATION
- U.S. GOVERNMENT INTERACTIONS – DEPENDENCE ON USG BUSINESS AND MANUFACTURING LINES INTEGRATION
- IMPACTS OF CHANGE IN USG DEFENSE DEMAND
Federal Agencies Supported by U.S. Bare Printed Circuit Board Facilities

- **U.S. Navy**: 18 Direct, 12 Both, 60 Indirect
- **National Aeronautics & Space Administration (NASA)**: 18 Direct, 9 Both, 38 Indirect
- **U.S. Army**: 6 Direct, 12 Both, 63 Indirect
- **National Oceanic & Atmospheric Administration (NOAA)**: 6 Direct, 3 Both, 13 Indirect
- **U.S. Air Force**: 5 Direct, 26 Both, 61 Indirect
- **Other**: 4 Direct, 7 Both
- **Department of Energy (DOE)**: 3 Direct, 26 Both
- **U.S. Intelligence Community**: 20 Direct
- **U.S. Marine Corps**: 40 Direct
- **Department of Homeland Security (DHS)**: 28 Direct
- **Missile Defense Agency (MDA)**: 47 Direct

115 Facilities reported 526 instances of direct or indirect support to USG Agencies
USG Programs

• 202 U.S. Bare PCB manufacturing facilities estimated that they have directly or indirectly supported 3,615 USG programs since 2012:

• Survey respondents identified 512 specific USG programs.

Top USG Agencies Identified for 512 Programs

- U.S. Air Force: 139
- U.S. Navy: 120
- U.S. Army: 100
- MDA - Missile Defense Agency: 32
- NASA - National Aeronautics & Space Administration: 21
- U.S. Marine Corps: 19
- Other: 7

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
USG Programs

Over 300 Systems Utilize U.S. Bare Printed Circuit Boards

Top USG Programs Identified

- Joint Strike Fighter (JSF): 17 facilities
- Long Range Discrimination Radar (LRDR): 12 facilities
- Patriot Missile: 11 facilities
- Air and Missile Defense Radar (AMDR): 10 facilities
- Space Fence: 8 facilities
- F-15 Aircraft: 8 facilities

Q4a,B

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

65 respondents
USG Programs
Bare PCB Products Supporting USG Systems (2012-2015)

Types of Bare PCBs Manufactured By U.S. Facilities for 512 USG Programs

- Rigid: 400
- Flex: 144
- Rigid-Flex: 233

Q4a,B

Source: U.S. Department of Commerce, Bureau of Industry and Security
USG Programs

Primary Methods Used to Find USG Business Opportunities

- **Other**: 63
- **Prime Contractors**: 62
- **Word of Mouth**: 53
- **N/A**: 13
- **Federal Web Site**: 9
- **DOD Queries**: 2

Other includes: Sales Teams (Inside and Outside), Advertisement (Print and Internet), Do not seek USG business opportunities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
75 U.S. Bare PCB facilities reported providing support to USAF (2012-2015)

- 47 facilities reported dependence on U.S. Government for their continued viability
- Reported roughly 53% / 47% commercial end-use / defense end-use sales split

Bare PCB Facility Size by Annual Sales (2015)

- 8 facilities are Small <$10M
- 37 facilities are Medium $10M-$40M
- 30 facilities are Large >$40M

Financial Risk Rating

- 46 facilities are Low/Neutral Risk
- 22 facilities are Moderate/Elevated Risk
- 3 facilities are High/Severe Risk
- Uncalculated

Primary Expected Change in Operations 2016-2020

- Modernization: 31 facilities
- Expansion: 23 facilities
- None: 13 facilities
- Potential Closure: 5 facilities
- Other: 2 facilities
- Contraction: 1 facility

Top USAF Programs Supported:

- Joint Strike Fighter
- Paveway
- AMRAAM
- SDB
- MEADS
- F-15
- F-16
- JASSM
- APKWS
- F-22
- ATFLIR
- F-35
- Space Fence

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

75 Respondents
90 U.S. Bare PCB facilities reported providing support to the U.S. Navy (2012-2015)

- 47 facilities reported dependence on U.S. Government for their continued viability
- Reported roughly 58% / 42% commercial end-use / defense end-use sales split

Bare PCB Facility Size by Annual Sales (2015)

- Small <$10M: 8
- Medium $10M-$40M: 48
- Large >$40M: 34

Primary Expected Change in Operations 2016-2020

- Modernization: 25
- Expansion: 2
- None: 18
- Potential Closure: 6
- Other: 2
- Contraction: 2

Financial Risk Rating

- High/Severe Risk: 33
- Moderate/Elevated Risk: 27
- Low/Neutral Risk: 57
- Uncalculated

U.S. Navy Programs Supported Include:

- AMDR
- Naval Undersea Warfare Center
- AGR4
- NLOS Missiles
- F-18
- P8A Poseidon
- F35 Joint Strike Fighter
- SM2
- JDAMs
- Spy3
- MK48
- Standard Missile SM-3
- NAVAL RESEARCH LAB
- TPY-53

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
81 U.S. Bare PCB facilities reported providing support to the U.S. Army (2012-2015)

- 45 facilities reported dependence on U.S. Government for their continued viability
- Reported roughly 55% / 45% commercial end-use / defense end-use sales split

### Financial Risk Rating

- High/Severe Risk: 4
- Moderate/Elevated Risk: 3
- Low/Neutral Risk: 23
- Uncalculated: 51

### U.S. Army Programs Supported Include:

- Abrams ECP1
- AH-64 Apache
- BLACKHAWK
- Enhanced Night Vision Goggles
- ENVG
- Excalibur
- Falcon II / III
- GMLRS
- Patriot
- THAAD
- Tomahawk
- JAVELIN
- KIV-77
- Manpack
- Missile Defense
- PAC-3

### Bare PCB Facility Size by Annual Sales (2015)

- Small <$10M: 10
- Medium $10M-$40M: 30
- Large >$40M: 41

### Primary Expected Change in Operations 2016-2020

- Modernization: 27
- Expansion: 31
- None: 15
- Potential Closure: 4
- Other: 2
- Contraction: 2

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Missile Defense Agency (MDA)

- 50 U.S. Bare PCB facilities reported providing support to MDA (2012-2015)
  - 40 facilities reported dependence on U.S. Government for their continued viability
  - Reported roughly 52% / 48% commercial end-use / defense end-use sales split

Bare PCB Facility Size by Annual Sales (2015)

- Small <$10M
- Medium $10M-$40M
- Large >$40M

Primary Expected Change in Operations 2016-2020

- Modernization: 18 facilities
- Expansion: 16 facilities
- None: 11 facilities
- Potential Closure: 2 facilities
- Other: 2 facilities
- Contraction: 1 facility

Financial Risk Rating

- High/Severe Risk
- Moderate/Elevated Risk
- Low/Neutral Risk
- Uncalculated

MDA Programs Supported Include:

- LRDR
- Space Fence
- Patriot Missiles
- THAAD Missiles
- Standard Missile 3
- EKV
- AMDR
- CWEB
- SM2 and SM3 Missile Program
- THAAD
- ICBM
- ABMD

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
National Aeronautics and Space Administration (NASA)

- 65 U.S. Bare PCB facilities reported providing support to NASA (2012-2015)
  - 40 facilities reported dependence on U.S. Government for their continued viability
  - Reported roughly 55% / 45% commercial end-use / defense end-use sales split

Bare PCB Facility Size by Annual Sales (2015)

<table>
<thead>
<tr>
<th>Size Category</th>
<th>Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small &lt;$10M</td>
<td>8</td>
</tr>
<tr>
<td>Medium $10M-$40M</td>
<td>23</td>
</tr>
<tr>
<td>Large &gt;$40M</td>
<td>34</td>
</tr>
</tbody>
</table>

Primary Expected Change in Operations 2016-2020

<table>
<thead>
<tr>
<th>Change Type</th>
<th># of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modernization</td>
<td>28</td>
</tr>
<tr>
<td>Expansion</td>
<td>21</td>
</tr>
<tr>
<td>None</td>
<td>9</td>
</tr>
<tr>
<td>Potential Closure</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>Contraction</td>
<td>1</td>
</tr>
</tbody>
</table>

Financial Risk Rating

<table>
<thead>
<tr>
<th>Risk Rating</th>
<th>Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe Risk</td>
<td>32</td>
</tr>
<tr>
<td>Moderate/Elevated Risk</td>
<td>20</td>
</tr>
<tr>
<td>Low/Neutral Risk</td>
<td>40</td>
</tr>
<tr>
<td>Uncalculated</td>
<td>4</td>
</tr>
</tbody>
</table>

NASA Programs Supported Include:

- SLS
- JUDY FLEX J1-001
- JUDY FLEX J3-001
- SDO
- JUSWST
- Dragon Capsule
- Orion Crew Vehicle
- AEHF
- Mars Pathfinder
- Space Cube
- Mars Curiosity
- Mars Rover
- GEOS
- Atlas 4
- Orion Crew Vehicle

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

65 Respondents
USG Interactions

USG Dependence and Manufacturing Lines Integration

Respondents were asked to indicate whether they consider themselves dependent on USG programs for their continued viability. Additionally, if the facility supported USG programs, respondents were asked to state whether the associated manufacturing lines were integrated with, or separate from its commercial manufacturing lines.

58 facilities (29 percent) considered themselves dependent on USG programs.

- This included facilities whose customers are the USG or USG contractors.
- Respondent feedback suggested that U.S. bare PCB manufacturing facilities that support the USG have become increasingly dependent on USG programs. As PCB commercial business has shifted offshore, and as U.S. bare PCB manufacturers have become less competitive globally in terms of pricing, USG and defense-related business has become responsible for a greater proportion of sales.

Almost all of the respondents (119 facilities) replied that both commercial and USG programs manufacturing lines are integrated. Only two facilities stated that they run segregated manufacturing lines.

- Respondent feedback expresses that running segregated manufacturing lines would be cost prohibitive and inefficient. Many facilities, particularly smaller ones, lack the equipment to run separate manufacturing lines.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017
Does this facility consider itself dependent on U.S. Government programs for its continued viability?

“35% of our business comes from U.S. Government contracts. It would difficult to survive without it.

“Absolutely - without our defense work, this facility would not be viable.”

“As a company whose end customer base is primarily military prime contractors, our existence revolves around USG programs.”

“As commercial business has moved off shore we have increased reliance on USG business.”

“Cannot compete in the commercial market because of Asian pricing.”

“There is no longer enough commercial work within the U.S. We depend on defense-based programs to keep viable.”
USG Interactions

Commercial and USG Manufacturing Lines Integration (2015)

If this facility's bare circuit board manufacturing supports USG programs, whether directly or indirectly, are the associated manufacturing lines integrated with, or separate from, its commercial manufacturing lines?

- "All product is treated with the same process equipment and process control standards."
- "Commercial and USG programs run on the same manufacturing equipment/lines."
- "Just one manufacturing line. Different classes have different test requirements."
- "Products covered by ITAR are kept segregated, but same lines are utilized."
- "Running segregated manufacturing lines for different end users …would increase cost."
- "The same capital equipment is used for flex circuit manufacturing, regardless of end market."
- "We manufacture with a single processing guideline with is associated with the IPC 600 guideline."
- "Our size does not allow us to separate our manufacturing."

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
USG Interactions
Effects of Change in USG Defense Demand (2015)

Respondents were asked to identify the impacts on a number of business operations that a sudden change in direct and/or indirect USG demand for electronic product containing bare PCBs would have. Responses were provided for both the scenarios of a sudden increase and a sudden decrease in USG defense demand.

- The greatest impact of a sudden increase in USG demand would be an increase in participation in USG contracts, capital and research and development expenditures, level of key production equipment, increase in skilled personnel, and improving organizational viability.
- A sudden decrease in USG demand would reduce industry participation in USG contracts, reduce capital and research and development expenditures, decrease skilled personnel, and have a negative effect on organizational viability/solvency. Additionally, it would likely result in increased product/service costs for a number of U.S. bare PCB manufacturers.

```
<table>
<thead>
<tr>
<th>Impact of sudden DECREASE in USG Defense Demand</th>
<th>Business Operation</th>
<th>Impact of sudden INCREASE in USG Defense Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change or N/A</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>128</td>
<td>66</td>
<td>2</td>
</tr>
<tr>
<td>149</td>
<td>48</td>
<td>5</td>
</tr>
<tr>
<td>129</td>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>136</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>146</td>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>154</td>
<td>46</td>
<td>2</td>
</tr>
<tr>
<td>172</td>
<td>26</td>
<td>4</td>
</tr>
<tr>
<td>167</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>170</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>188</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Movement of Operations to Non-U.S. Locations</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>
```

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 Respondents
Impact of USG Demand Change
Industry Comments:

• “A decrease in USG demand would drive companies presently engaged in supporting USG programs to compete in our niche. An increase in USG demand for printed circuits would create opportunities for the entire U.S. manufacturing base.”

• “Greatest impact from a sudden decrease would be from competitors with higher dependence on government spending. They would try to take business from each other and us, by undercutting in last attempt to stay alive. This could result in short term profitability hit to the entire industry, and jeopardize the U.S. infrastructure.”

• “If the USG decreases demand suddenly it will affect raw material and supply pricing for the whole industry in a negative manner. If the USG increased its need to buy PCBs suddenly we may find our facility doing more USG work if our services were needed.”

• “The trickle-down effect of DOD/Homeland Security spending is significant to the printed circuit board supply chain and participants.”

Q4b,B

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Impact of USG Demand Change
Capital Expenditures (CAPEX)

A change in USG demand would have an effect on industry CAPEX, with an increase in USG demand having a higher impact than a decrease. Over half of respondents (52 percent) stated that their CAPEX would rise with increased USG demand, compared to 32 percent stating that their CAPEX would be reduced with decreased USG demand.

<table>
<thead>
<tr>
<th>Impact of sudden DECREASE in USG Defense Demand</th>
<th>Business Operation</th>
<th>Impact of sudden INCREASE in USG Defense Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change or N/A</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>128</td>
<td>66</td>
<td>2</td>
</tr>
</tbody>
</table>

INDUSTRY COMMENTS:

“CapEx primarily dependent on overall business levels.”
“Dependent on level of increase.”
“Dependent on size of increase; May need additional equipment for production.”
“Only legacy and as-needed equipment would be replaced.”
“Our current capital budget would be little influenced by the types of jobs we know are tied to the USG.”
“We adjust our Capex plans based on demand.”
“Decrease would impact ability to invest. Increase may increase Cap Ex but not typically.”
Impact of USG Demand Change
Industry Comments: Research and Development Expenditures

A change in USG demand would impact industry R&D expenditures, with an increase in USG demand having a slightly higher impact than a decrease. Thirty percent of respondents stated that their R&D expenditures would rise with increased USG demand, compared to 24 percent stating that their R&D expenditures would be reduced as a result of decreased USG demand.

<table>
<thead>
<tr>
<th>Impact of sudden DECREASE in USG Defense Demand</th>
<th>Business Operation</th>
<th>Impact of sudden INCREASE in USG Defense Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change or N/A</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>149</td>
<td>48</td>
<td>5</td>
</tr>
</tbody>
</table>

**INDUSTRY COMMENTS:**

- “Internal independent research and development (IRAD) would follow the business case.”
- “Our development efforts would increase as we are targeting the defense market for long term revenue and profitability.”
- “R&D investment is done based on the need.”
- “[Increased USG] spending results in more complex products which require R&D.”
- “We do not have an R&D budget.”
Impact of USG Demand Change
Industry Comments: Organizational Viability/Solvency

A change in USG demand would impact organizational viability/solvency in the industry, with an increase in USG demand having a slightly higher impact than a decrease. Thirty-seven percent of respondents stated that their organizational viability/solvency would improve with increased USG demand, compared to 25 percent stating that their organizational viability/solvency would be reduced as a result of decreased USG demand.

<table>
<thead>
<tr>
<th>Impact of sudden DECREASE in USG Defense Demand</th>
<th>Business Operation</th>
<th>Impact of sudden INCREASE in USG Defense Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change or N/A</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>146</td>
<td>50</td>
<td>6</td>
</tr>
</tbody>
</table>

**INDUSTRY COMMENTS:**

- “Dependent on size of increase.”
- “Every bit of business helps.”
- “Increase in production will increase viability.”
- “Mil / Aero / Defense is very important to this facility.”
- “Our commercial based customers would suffer.”
- “We would anticipate less price pressure on the parts we are building.”
- “Depends on level of demand change; depth of decrease.”
- “If not profitable because of loss of volume, the company fails.”
- “The integrity of the organization could be challenged.”
Impact of USG Demand Change

Industry Comments: Level of Key Production Equipment

A change in USG demand would impact industry levels of key production equipment, with an increase in USG demand having a higher impact than a decrease. Forty-eight percent of respondents stated that their levels of key production equipment would increase with increased USG demand, compared to 15 percent stating that their levels of key production equipment would decrease as a result of decreased USG demand.

<table>
<thead>
<tr>
<th>Impact of sudden DECREASE in USG Defense Demand</th>
<th>Business Operation</th>
<th>Impact of sudden INCREASE in USG Defense Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change or N/A</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>170</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>170</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

**INDUSTRY COMMENTS:**

- “Capital purchases for capacity.”
- “May need additional equipment for technology or production.”
- “Our current capital budget would be little influenced by the types of jobs tied to the USG.”
- “When profitable upgrades can be invested in.”
- “Possibly would increase [equipment requirements] depending on the increase.”
- “Same equipment. No changes.”
- “Short term capacity utilization would be impacted.”
CHAPTER 4: BARE PCB MANUFACTURING

- MANUFACTURING CAPABILITIES
- MANUFACTURING STANDARDS
- MANUFACTURING PRODUCTION AND CAPACITY
Facility Manufacturing Capabilities
Types of Boards: Tin Lead/Lead Free (2015)

U.S. Bare PCB Facilities Manufacturing Capabilities

- Both Tin-Lead and Lead-Free: 184 facilities
- Lead Free Only: 15 facilities
- Tin-Lead Only: 3 facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
202 respondents
Facility Manufacturing Capabilities

U.S. Bare PCB Manufacturing Capabilities – Types of Boards (2015)

- Tin-Lead Only
- Lead-Free Only
- Both Tin-Lead and Lead-Free

Rigid Conventional Boards (single-sided or double-sided)
Rigid Multilayer Boards
Rigid High Speed Boards
Rigid High Frequency Boards
Rigid Microwave Boards
Flexible Conventional Boards (single-sided or double-sided)
Flexible Multilayer Boards
Rigid-Flex Hybrid Boards
Flexible High Frequency Boards
Flexible High Speed Boards
Flexible Microwave Boards
Integrated Circuit Package Substrates

Number of Facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
Facility Manufacturing Capabilities
Minimum Bare PCB Inner Layer (Core) Thickness (2015)

What is the minimum inner layer (core) thickness of circuit board components that this facility can produce?

- N/A: 2
- Less than 0.001": 18
- 0.001": 48
- 0.002": 42
- 0.003": 31
- 0.004": 19
- 0.005": 22
- More than 0.005": 20

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Maximum Bare PCB Thickness (2015)

What is the maximum bare circuit board thickness that this facility can achieve?

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>1</td>
</tr>
<tr>
<td>Less than 0.01&quot;</td>
<td>7</td>
</tr>
<tr>
<td>0.01&quot;</td>
<td>7</td>
</tr>
<tr>
<td>0.02&quot;</td>
<td>12</td>
</tr>
<tr>
<td>More than 0.02&quot;</td>
<td>175</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities – Printed Electronics (PE)

- Twenty-seven Bare PCB facilities manufacture printed electronics (PE) (2015)
  - "Printed Electronics" refers to the use of additive printing methods on flexible substrates such as plastic, paper, epoxy-fiberglass, textiles, and other electronic devices such as discrete electronic components, sensors, and others.

![Bar Chart]

Q5a, C

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
## Facility Manufacturing Capabilities
### Printed Electronics (PE): Comments

<table>
<thead>
<tr>
<th></th>
<th>Commercial</th>
<th>Government Defense</th>
<th>Government Non-Defense</th>
<th>University / Non-Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full Production</strong></td>
<td>• Automotive Actuators, Resistive Circuitry</td>
<td>• PE to defense, medical, and aerospace industries</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Flexible PE from bare to assembly (medical devices and equipment)</td>
<td>• RF Electronics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Printing on copper and fiberglass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Print conductive ink on plastic films (automotive, medical, and commercial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Limited Production</strong></td>
<td>• Flex components/Thin FR 4</td>
<td>• Epoxy Fiberglass/Polyimide (Military)</td>
<td>• Embedded resistors and resistive etch capabilities (commercial/non-defense)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Developing new additive technology called [Redacted]</td>
<td>• Thick film resistors</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R&amp;D Only</strong></td>
<td>• Prototype Projects</td>
<td>• Evaluating eSurface process (R&amp;D for OEMs)</td>
<td></td>
<td>• Prototypes (consortia for future applications)</td>
</tr>
<tr>
<td></td>
<td>• R&amp;D Development for customers (touch panels, wearables)</td>
<td>• Advanced PE Development (for DoD systems)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Q5a,C**

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities

Bare PCB External Layer Standard Trace Width (in inches)

Copper Conductor Weights

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
External Layer: Minimum Trace Width (2015)

Bare PCB External Layer Minimum Trace Width (in inches)

Copper Conductor Weights

Q5a,D

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
Facility Manufacturing Capabilities

Bare PCB Internal Layer Standard Trace Width (in inches)

- N/A
- Less than 0.001"
- 0.001"
- 0.002"
- 0.003"
- 0.004"
- 0.005"
- More than 0.005"

Copper Conductor Weights

0.25 oz copper
0.5 oz copper
1 oz copper
2 oz copper
3-5 oz copper
6-10 oz copper
10+ oz copper

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Internal Layer: Minimum Trace Width (2015)

Bare PCB Internal Layer Minimum Trace Width (in inches)

<table>
<thead>
<tr>
<th>Copper Conductor Weights</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 oz copper</td>
<td></td>
</tr>
<tr>
<td>0.5 oz copper</td>
<td></td>
</tr>
<tr>
<td>1 oz copper</td>
<td></td>
</tr>
<tr>
<td>2 oz copper</td>
<td></td>
</tr>
<tr>
<td>3-5 oz copper</td>
<td></td>
</tr>
<tr>
<td>6-10 oz copper</td>
<td></td>
</tr>
<tr>
<td>10+ oz copper</td>
<td></td>
</tr>
</tbody>
</table>

Q5a,D
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities

Bare PCB External Layer Standard Space Width (in inches)

Copper Conductor Weights

0.25 oz copper 0.5 oz copper 1 oz copper 2 oz copper 3-5 oz copper 6-10 oz copper 10+ oz copper

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Facility Manufacturing Capabilities

Bare PCB External Layer Minimum Space Width (in inches)

- N/A
- Less than 0.001"
- 0.001"
- 0.002"
- 0.003"
- 0.004"
- 0.005"
- More than 0.005"

Number of Facilities

Copper Conductor Weights

0.25 oz copper 0.5 oz copper 1 oz copper 2 oz copper 3-5 oz copper 6-10 oz copper 10+ oz copper

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities

Bare PCB Internal Layer Standard Space Width (in inches)

Copper Conductor Weights

Q5a,E

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Internal Layer: Minimum Space Width (2015)

Bare PCB Internal Layer Minimum Space Width (in inches)

Number of Facilities

Copper Conductor Weights

Q5a,E

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
Facility Manufacturing Capabilities – Specific Processes

- **Photo imaging**: 186, 187
- **LPI solder mask**: 186, 185
- **Screen printing**: 182, 185
- **Controlled drilling/milling**: 174, 180
- **Hot air solder level tin-lead**: 152, 157
- **Hot air solder level lead-free**: 118, 115
- **Direct imaging**: 95, 115
- **Automated electrolytic copper plating**: 91, 114
- **Automated electroless copper plating**: 86, 113
- **Dry film solder mask**: 85, 110
- **Direct metallization plating**: 89, 106
- **Thermal management structures**: 86, 101
- **Fully additive plating**: 87, 97
- **Laser ablation**: 72, 97
- **Z-axis interconnect technology**: 65, 85
- **Opto-electronic structures**: 67, 83
- **Other processes identified include**: ENIG, Fusion bonding, LPI LDI solder mask, Multiple surface finishes, Polymer thick films, Sputtering, Teflon etching.

**Q5b,A**

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Other Processes Reported

- Buried capacitance
- ENEPIG
- ENIG
- ENIG, gold tab, silver
- Fusion bonding
- Immersion Tin, Imm. Silver and OSP
- Laser-direct solder mask
- LPI LDI solder mask
- Manual electroless copper
- Multiple surface finishes
- Organic solderability protectant

- Plating process is semi auto
- Polymer thick films
- Screened resistors, digital and microwave circuit on one homogenous plane, Rohacell, closed-cell foam boards and special application processes.
- Sputtering
- Teflon etching
- Tin silver
- Tin/Lead plate and fuse
- White tin, gold, spray printing, other

Other processes identified include: ENIG, Fusion bonding, LPI LDI solder mask, Multiple surface finishes, Polymer thick films, Sputtering, Teflon etching, Tin silver
Facility Manufacturing Capabilities
Maximum Circuit Layers per Board


<table>
<thead>
<tr>
<th>Maximum Circuit Layers per Board</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>47</td>
</tr>
<tr>
<td>11-20</td>
<td>54</td>
</tr>
<tr>
<td>21-30</td>
<td>42</td>
</tr>
<tr>
<td>31-40</td>
<td>27</td>
</tr>
<tr>
<td>41-50</td>
<td>14</td>
</tr>
<tr>
<td>51-99</td>
<td>17</td>
</tr>
<tr>
<td>100+</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q5b,B

202 respondents
Facility Manufacturing Capabilities
Maximum Sequential Laminations per Board

Maximum Capability for Sequential Laminations (2015)

<table>
<thead>
<tr>
<th>Maximum Sequential Laminations per Board</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td>1-5</td>
<td>104</td>
</tr>
<tr>
<td>6-10</td>
<td>34</td>
</tr>
<tr>
<td>11-20</td>
<td>14</td>
</tr>
<tr>
<td>21-30</td>
<td>5</td>
</tr>
<tr>
<td>31-40</td>
<td>1</td>
</tr>
<tr>
<td>41-50</td>
<td>0</td>
</tr>
<tr>
<td>50+</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
### Facility Manufacturing Capabilities

**Maximum Impedance Structures per Board**

**Maximum Capability for Impedance Structures (2015)**

<table>
<thead>
<tr>
<th>Maximum Impedance Structures per Board</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>1-5</td>
<td>53</td>
</tr>
<tr>
<td>6-10</td>
<td>29</td>
</tr>
<tr>
<td>11-20</td>
<td>29</td>
</tr>
<tr>
<td>21-30</td>
<td>8</td>
</tr>
<tr>
<td>31-40</td>
<td>7</td>
</tr>
<tr>
<td>41-50</td>
<td>3</td>
</tr>
<tr>
<td>51-100</td>
<td>5</td>
</tr>
<tr>
<td>100+</td>
<td>3</td>
</tr>
</tbody>
</table>

3 facilities reported maximum impedance structures per board of 500, 10,000, and 1,000,000 each.

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Maximum Stacked Micro Vias per Board


- 115 facilities reported maximum stacked micro vias per board of 200,000
- 56 facilities reported maximum stacked micro vias per board of 1,000,000

2 facilities reported maximum stacked micro vias per board of 200,000, and 1,000,000 each

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q5b,B 202 respondents
Facility Manufacturing Capabilities

Maximum Staggered Micro Vias per Board


2 facilities reported maximum staggered micro vias per board of 200,000, and 1,000,000 each

Number of Facilities

Maximum Staggered Micro Vias per Board

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
### Facility Manufacturing Capabilities

**PCB Via Fill and Planarization: Locations and Process Methods**

Identify where the bare circuit board via fill and planarization manufacturing activities are performed for this facility (2015):

<table>
<thead>
<tr>
<th>Location</th>
<th>Process Method</th>
<th>Automatic</th>
<th>Manual</th>
<th>Both</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>This facility</strong></td>
<td></td>
<td>28</td>
<td>44</td>
<td>39</td>
<td>3</td>
</tr>
<tr>
<td>Contractor-operated U.S. facilities</td>
<td></td>
<td>35</td>
<td>9</td>
<td>25</td>
<td>9</td>
</tr>
<tr>
<td>Other company-owned U.S. facilities</td>
<td></td>
<td>15</td>
<td>5</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Contractor-operated non-U.S. facilities</td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other company-owned non-U.S. facilities</td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: U.S. Department of Commerce, Bureau of Industry and Security*

*202 respondents*
Facility Manufacturing Capabilities
PCB Via Fill and Planarization: Locations and Process Methods

**Process Methods: This Facility**

- Automatic: 28
- Manual: 44
- Both: 39
- Neither: 3
- N/A: 3

**Automatic: Explanations**
- Automated tool with scavenger blade and horizontal conveyorized planarizer
- Copper via fill
- Custom equipment
- Liquid photo imageable via fill only
- Mass GmbH 300 via fill machine & Polo-Massa Planarizer
- Mass GmbH via fill, Polo-Massa planarizer
- Non-conductive fill / outside service for conductive fill
- Planarization only
- Polo-Massa equipment. Non-conductive fill material
- New equipment installed in Q2 2016

**Manual: Explanations**
- Conductive and non-conductive ink
- Flex manufacturer, planarization not employed
- In development at this time
- Non-conductive is primarily done in-house
- Processed at this facility
- Screened in with template
- Use of vibrating sander
- Do conductive via fill at this facility manually
- Use Ormet paste technology

**Both: Explanations**
- Auto via fill, manual planarizer
- Automatic for via fill and manual planarization
- Both auto and manual planarizer
- Combination of auto planarization and manual sanding is used
- Conductive & non-conductive via fill
- Manual and automated mass equipment
- Planarization only is done in-house
- Semi-automatic via fill & planarization
- Via fill and planarization performed in house
- Via fill automated, planarization manual
- Use auto and manual sanding and machine assisted fill
- Wise planarizer and ITC via fill on premises

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
114 respondents
Facility Manufacturing Capabilities

PCB Via Fill and Planarization: Locations and Process Methods

**Process Methods:**
Other company-owned U.S. facilities

- **Automatic:** Explanations
  - Use local supplier
  - Outside service

- **Manual:** Explanations
  - Non-conductive fill / outside service for conductive fill

- **Both:** Explanations
  - Hand screened and planarized using automatic planarizer
  - Manual and automated Mass GmbH equipment
  - Ue HDI via fill for non-conductive materials

---

Q5b,C

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

34 respondents
Facility Manufacturing Capabilities
PCB Via Fill and Planarization: Locations and Process Methods

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q5b,C

78 respondents
Facility Manufacturing Capabilities
PCB Via Fill and Planarization: Locations and Process Methods

Process Methods:
Other company-owned non-U.S. facilities

- Automatic
- Manual
- Both
- Neither
- N/A

Both: Explanations

• Hand screened and planarized using automatic planarizer

Automatic: Explanations

• Commercial customer only

Q5b,C

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

3 respondents
Facility Manufacturing Capabilities
PCB Via Fill and Planarization: Locations and Process Methods

Process Methods:
Contractor-operated non-U.S. facilities

- Automatic
- Manual
- Both
- Neither
- N/A

Automatic: Explanations
- Planarizing Machine
Facility Manufacturing Capabilities
Via Structures

Via Formation Process Capabilities (2015)

<table>
<thead>
<tr>
<th>Process</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etchback</td>
<td>158</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>Chemical smear removal</td>
<td>149</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>Nonconductive via fill</td>
<td>134</td>
<td>59</td>
<td>9</td>
</tr>
<tr>
<td>Plasma etch</td>
<td>120</td>
<td>72</td>
<td>10</td>
</tr>
<tr>
<td>Micro-via solid copper fill</td>
<td>89</td>
<td>98</td>
<td>15</td>
</tr>
<tr>
<td>Laser via formation</td>
<td>75</td>
<td>115</td>
<td>12</td>
</tr>
</tbody>
</table>

Number of Facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Mechanically Drilled Vias

Via Structure Drilling Process Capabilities (2015)

- Mechanically drilled via: controlled-depth
- Mechanically drilled via: through-board

<table>
<thead>
<tr>
<th>Maximum Aspect Ratio</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5:1</td>
<td>10</td>
</tr>
<tr>
<td>5:1</td>
<td>26</td>
</tr>
<tr>
<td>10:1</td>
<td>34</td>
</tr>
<tr>
<td>15:1</td>
<td>44</td>
</tr>
<tr>
<td>20:1</td>
<td>43</td>
</tr>
<tr>
<td>25:1</td>
<td>3</td>
</tr>
<tr>
<td>30:1</td>
<td>4</td>
</tr>
<tr>
<td>Over 30:1</td>
<td>7</td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Capabilities
Laser-formed Micro Vias

Via Structure Drilling Process Capabilities (2015)

- Laser-formed Micro Via

<table>
<thead>
<tr>
<th>Maximum Aspect Ratio</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>Over 1:1</td>
<td>20</td>
</tr>
<tr>
<td>1:1</td>
<td>45</td>
</tr>
<tr>
<td>0.75:1</td>
<td>24</td>
</tr>
<tr>
<td>0.5:1</td>
<td>8</td>
</tr>
<tr>
<td>Under 0.5:1</td>
<td>4</td>
</tr>
<tr>
<td>N/A</td>
<td>99</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Standards (2015)

Standards Used by U.S. Bare PCB Facilities

<table>
<thead>
<tr>
<th>Standard</th>
<th>Formal Certification</th>
<th>Informal Use</th>
<th>Not Used</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>NADCAP</td>
<td>22</td>
<td>21</td>
<td>118</td>
<td>41</td>
</tr>
<tr>
<td>MIL-PRF 55110</td>
<td>55</td>
<td>48</td>
<td>73</td>
<td>26</td>
</tr>
<tr>
<td>MIL-PRF 50884</td>
<td>24</td>
<td>38</td>
<td>108</td>
<td>32</td>
</tr>
<tr>
<td>MIL-PRF 31032</td>
<td>42</td>
<td>47</td>
<td>85</td>
<td>28</td>
</tr>
<tr>
<td>ISO 9001</td>
<td></td>
<td></td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>IPC 6018</td>
<td>17</td>
<td>79</td>
<td>65</td>
<td>41</td>
</tr>
<tr>
<td>IPC 6017</td>
<td>3</td>
<td>51</td>
<td>99</td>
<td>49</td>
</tr>
<tr>
<td>IPC 6016</td>
<td>6</td>
<td>57</td>
<td>90</td>
<td>49</td>
</tr>
<tr>
<td>IPC 6015</td>
<td>4</td>
<td>49</td>
<td>100</td>
<td>49</td>
</tr>
<tr>
<td>IPC 6013</td>
<td>22</td>
<td>88</td>
<td>61</td>
<td>31</td>
</tr>
<tr>
<td>IPC 6012</td>
<td>47</td>
<td>118</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>IPC 6011</td>
<td>21</td>
<td>102</td>
<td>49</td>
<td>30</td>
</tr>
<tr>
<td>IPC 1071</td>
<td>4</td>
<td>58</td>
<td>95</td>
<td>45</td>
</tr>
<tr>
<td>AS 9100</td>
<td>69</td>
<td>39</td>
<td>67</td>
<td>27</td>
</tr>
</tbody>
</table>

Other Standards Used:
- AIAG
- AS9003
- IPC610
- IPC-A-600
- ISO 13485
- ISO 13548
- ISO 14001
- ISO/TS16949
- ISO13495
- ISO14001
- ITAR
- J-STD-01F
- TS16949
- UL

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Standards – MIL Certification

- Only 31% of U.S. PCB manufacturing facilities hold an official MIL certification.
  - MIL-PRF 31032: 42 total facilities (only 14 of 146 small)
  - MIL-PRF 50884: 24 total facilities (only 11 of 146 small)
  - MIL-PRF 55110: 55 total facilities (only 28 of 146 small)

- Comments:
  - “We recently dropped MIL certification due to increasing requirements burden.”
  - “Cost of compliance to MIL specs, etc. could result in a few suppliers getting all the business. Our business serves medical market, industrial market and military markets. Separate and unique certifications and systems compliance for each segment results in a lot of additional (LOW VALUE) effort and support.”
  - “We have avoided government space applications due to stringent testing and paperwork requirements. Needs a full time program manager with experience.”
  - “Testing & documentation relative to other customers is extreme.”

- Potential Actions:
  - Increase/create funding program to help small U.S. PCB manufacturers achieve formal certifications. (ex: MIL-PRF).
Facility Manufacturing Standards

Does This Facility Have an Active Technical Review Board

- Yes: 140 (69%)
- No: 62 (31%)

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Facility Manufacturing Standards
Inspection Methods and Capabilities (2015)

Number of facilities using identified methods for assuring conformance with performance requirements

- Primary Final Circuit Board Inspection Method
  - 100% Inspection: 131 facilities
  - Other: 35 facilities
  - Sampling: 20 facilities
  - C=0: 16 facilities

Number of facilities reporting that their first article inspection capabilities comply with AS 9102

- Yes: 141 facilities (70%)
- No: 55 facilities (27%)
- N/A: 6 facilities (3%)

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
Facility Manufacturing Standards
Forms of Testing Used for Bare PCB Performance (2015)

<table>
<thead>
<tr>
<th>Testing Form</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flying Probe</td>
<td>182</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Continuity 10 Volts DC, 10 Ohm Maximum</td>
<td>178</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Isolation 250 Volts DC, 100 MegaOhm Minimum</td>
<td>173</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Test all end points, no phase testing</td>
<td>162</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Impedance Testing with Plots</td>
<td>136</td>
<td>56</td>
<td>10</td>
</tr>
<tr>
<td>Bed-of-Nails</td>
<td>126</td>
<td>66</td>
<td>10</td>
</tr>
<tr>
<td>Interconnect Stress Testing (IST)</td>
<td>59</td>
<td>129</td>
<td>14</td>
</tr>
<tr>
<td>Highly Accelerated Thermal Shock (HATS)</td>
<td>38</td>
<td>145</td>
<td>19</td>
</tr>
<tr>
<td>Highly Accelerated Stress Testing (HAST)</td>
<td>23</td>
<td>158</td>
<td>21</td>
</tr>
<tr>
<td>Highly Accelerated Life Testing (HALT)</td>
<td>17</td>
<td>163</td>
<td>22</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Standards - Software

Facilities employing TrueChem or equivalent software to manage chemistries, coatings, and associated processes in bare printed circuit board production

- Yes: 105 (52%)
- No: 85 (42%)
- N/A: 12 (6%)

Facilities employing material requirements planning software in the operation bare printed circuit board manufacturing facilities in the U.S.

- Yes: 103 (51%)
- No: 89 (44%)
- N/A: 10 (5%)

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q5c,E 202 respondents
Facility Manufacturing Production and Capacity
Average Weekly Inner Layers (Cores) Manufactured (2012-2015)

<table>
<thead>
<tr>
<th>Average Weekly Inner Layers (Cores) Manufactured</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>32</td>
<td>30</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>11-100</td>
<td>36</td>
<td>37</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>101-500</td>
<td>58</td>
<td>57</td>
<td>57</td>
<td>63</td>
</tr>
<tr>
<td>501-1,000</td>
<td>26</td>
<td>25</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>1,001-10,000</td>
<td>44</td>
<td>47</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>10,000+</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
Facility Manufacturing Production and Capacity
Average Weekly Panels Manufactured (2012-2015)

<table>
<thead>
<tr>
<th>Number of Facilities</th>
<th>Average Weekly Panels Manufactured</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>18, 15, 13, 13</td>
</tr>
<tr>
<td>11-100</td>
<td>42, 42, 44, 46</td>
</tr>
<tr>
<td>101-500</td>
<td>88, 92, 88, 86</td>
</tr>
<tr>
<td>501-1,000</td>
<td>27, 24, 24, 27</td>
</tr>
<tr>
<td>1,000+</td>
<td>27, 29, 33, 30</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security  
U.S. Bare Printed Circuit Board Industry Assessment – 2017 
202 respondents
Facility Manufacturing Production and Capacity
Bare PCB Panels: Range of Sizes (2015)

U.S. Bare PCB Facilities – Panel Size Production Capability

Number of Facilities

Panel Size

- 24x36
- 24x30
- 21x24
- 18x24
- 12x24
- 12x18
- 9x12
- Other

27
44
88
178
120
175
125
74

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Inner Layers (Cores) Production Capacity Ranges for U.S. Bare PCB Facilities

- Number of Facilities: 23, 19, 51, 33, 76
- Number of Weekly Inner Layers (Cores): 0-10, 11-100, 101-500, 501-1,000, 1,000+

Panel Production Capacity Ranges for U.S. Bare PCB Facilities

- Number of Facilities: 6, 25, 72, 50, 49
- Number of Weekly Panel Units: 0-10, 11-100, 101-500, 501-1,000, 1,000+

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents

- How many 8-hour production shifts does this facility typically operate per day?
- How many 8-hour production shifts per day COULD this facility operate practically?
- How many 8-hour front-end engineering shifts does this facility typically operate per day?
- How many 8-hour front-end engineering shifts per day COULD this facility operate practically?

Number of Facilities

<table>
<thead>
<tr>
<th>Number of 8-hour Production Shifts</th>
<th>0 Shifts</th>
<th>1 Shift</th>
<th>2 Shifts</th>
<th>3 Shifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Shifts</td>
<td>4</td>
<td>1</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>1 Shift</td>
<td>95</td>
<td>24</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>2 Shifts</td>
<td>130</td>
<td>49</td>
<td>43</td>
<td>69</td>
</tr>
<tr>
<td>3 Shifts</td>
<td>128</td>
<td>13</td>
<td></td>
<td>83</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Production and Capacity
Production Shift Capability: Comments

- “2nd & 3rd shifts are partial coverage shifts”
- “3rd shift is currently very lightly staffed”
- “Additional shifts are dependent on the ability to hire qualified operators”
- “All engineering is done outside the company”
- “Based on current production requirements the board shop department of the company only operates one shift, the first shift”
- “Company could run 24-hours-a-day with proper personnel”
- “Currently capacity is not an issue, and could increase engineering staff to accommodate business needs if so required”
- “Currently one full shift with a small swing shift”
- “Currently work 1 full shift; partial coverage on 2nd shift for bottleneck areas”
- “Expansion to a third shift is possible; not probable at current production levels”
- “Factors are availability of trained personnel and work amount available”
- “If work is there, we can hire people to work 24/7”
- “Limited availability of sufficiently skilled personnel”
- “Methods engineering and CAM Engineering reduced staff on 2nd, 3rd shifts”
- “With more work we would work more hours”
- “No demand for bare boards to operate facility to capacity. Lack of available experienced operator and engineers”

- “Production typically is 4 days per week, 6-hour shift days”
- “Run 7 days x 24 hours using variety of shifts”
- “Saturday/Sunday used for overtime and maintenance”
- “Since 2012 we have been on mostly 4 days at 8 hours a day only and very few 5 days a week”
- “Facility is running at nearly 70% of capacity and limited to 2 (9 hour) shifts.”
- “Third shift does exist but very minimally staffed (<10 associates); Room for both 2nd and 3rd shift to significantly increase”
- “We work what it takes to manufacture the specialty boards round the clock”
- “We are currently running under capacity”
- “We are open 24 hours M-F with Saturdays as needed”
- “We could run a whole second shift but we would need to add employees “
- “Downsized to stay open but we have the capability of ramping up”
- “We have room to grow in production and engineering”
- “Roster of 8 employee’s two of which are engineers”
- “We operate a daily split shift, operating from 7AM to 8PM with 18 employees”
- “Work load is currently extremely low. Most employees are gone. Equipment and facility capable of 3 shifts provided the work load is there”
- “Other than a skeleton crew of 2 or 3 workers, the 3rd shift is open for additional production and front-end engineering”
Facility Manufacturing Production and Capacity
U.S. Bare PCB Facility Utilization Rate (2012–2015)

*Average manufacturing utilization rate for each of the years 2012-2015, as a percentage of production possible under a 7 day-per-week, 24-hour-per-day operation.*
Facility Manufacturing Production and Capacity Raising Production Output From Current Levels (2015)

- Estimate how many weeks it would take to raise this facility's production from current levels to 100% capacity utilization:
- Estimate how many weeks it would take to raise this facility's production from current levels to 150% of your current capacity utilization:

Estimates of Weeks Needed

Q5d,F

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

- **Availability or cost of workforce**: 154 (143) 134
- **Amount of equipment**: 82 82 101
- **Quality control**: 74 82 64
- **Availability of equipment**: 64 63 56
- **Availability of input materials**: 56 82 45
- **Manufacturing space**: 45 82
- **Other**: 14 16

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Facility Manufacturing Production and Capacity Anticipated Changes in Bare PCB Product Lines by 2020

How does this facility anticipate the range of bare circuit board product lines it manufactures will change by 2020?

<table>
<thead>
<tr>
<th>Product Line</th>
<th>Increase</th>
<th>Decrease</th>
<th>No Change</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Circuit Package Substrates</td>
<td>39</td>
<td>3</td>
<td>29</td>
<td>131</td>
</tr>
<tr>
<td>Flexible Multilayer Boards</td>
<td>68</td>
<td>7</td>
<td>25</td>
<td>102</td>
</tr>
<tr>
<td>Flexible Microwave Boards</td>
<td>51</td>
<td>4</td>
<td>29</td>
<td>118</td>
</tr>
<tr>
<td>Flexible High Speed Boards</td>
<td>61</td>
<td>4</td>
<td>27</td>
<td>110</td>
</tr>
<tr>
<td>Flexible High Frequency Boards</td>
<td>60</td>
<td>4</td>
<td>26</td>
<td>112</td>
</tr>
<tr>
<td>Flexible Conventional Boards (single-sided or double-sided)</td>
<td>55</td>
<td>17</td>
<td>41</td>
<td>89</td>
</tr>
<tr>
<td>Rigid-Flex Hybrid Boards</td>
<td>72</td>
<td>4</td>
<td>23</td>
<td>103</td>
</tr>
<tr>
<td>Rigid Multilayer Boards</td>
<td>102</td>
<td></td>
<td>33</td>
<td>44</td>
</tr>
<tr>
<td>Rigid Microwave Boards</td>
<td>103</td>
<td>13</td>
<td>40</td>
<td>46</td>
</tr>
<tr>
<td>Rigid High Speed Boards</td>
<td>115</td>
<td>12</td>
<td>32</td>
<td>43</td>
</tr>
<tr>
<td>Rigid High Frequency Boards</td>
<td>115</td>
<td>14</td>
<td>31</td>
<td>42</td>
</tr>
<tr>
<td>Rigid Conventional Boards (single-sided or double-sided)</td>
<td>31</td>
<td>88</td>
<td>63</td>
<td>20</td>
</tr>
</tbody>
</table>

Q5e,A

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Facility Manufacturing Production and Capacity Anticipated Changes in Front-End Engineering Capability by 2020

How does this facility anticipate it’s front-end engineering processing capabilities will change by 2020?

<table>
<thead>
<tr>
<th></th>
<th>Increase</th>
<th>Decrease</th>
<th>No Change</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>108</td>
<td>21</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Defense</td>
<td>93</td>
<td>55</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Facility Manufacturing Production and Capacity

Front-end Bare PCB Engineering: In-House (2015)

Does this facility have its own staff on site to perform front-end engineering for manufacturing bare circuit boards?

- Yes: 193
- No: 9

Does this facility perform front-end engineering for manufacturing bare circuit boards as a service to other companies that may have bare circuit boards manufactured elsewhere?

- Yes: 175
- No: 27

Source: U.S. Department of Commerce, Bureau of Industry and Security
Facility Manufacturing Production and Capacity
Front-end Bare PCB Engineering: Outsource (2015)

Does this facility outsource any front-end engineering for bare circuit board products manufactured at this facility?

- Yes: 34
- No: 165
- N/A: 3

Number of Facilities: 200

Does your company notify customers in advance that it outsources front-end engineering for manufacturing bare circuit boards?

- Yes: 24
- No: 19
- N/A: 159

Number of Facilities: 200

If this facility outsources front-end engineering for bare circuit board products, indicate the country or countries (including the United States) to which this service is outsourced:

- Commercial Work Locations:
  - India: 17
  - China: 3
  - Philippines: 1

Number of Facilities:

- Defense Work: 0
- Commercial Work: 21
Facility Manufacturing Production and Capacity
Primary Factors Causing Production Bottlenecks (2015)

Identify the three most significant factors causing production bottlenecks at this facility. (512 responses)

Most "Other" responses cited workforce factors, machine, material and technological limitations, or that there are no existing bottlenecks.

Q5e,D

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
CHAPTER 5:
MATERIALS AND EQUIPMENT

• MATERIALS - SOURCING AND SUPPLY CHAIN
• EQUIPMENT
Bare PCB Supply Chain

• U.S. PCB manufacturers are confronted with a diminished supply chain as well as diminishing number of downstream customers.
  ➢ PCB are intermediate products, not end products. As electronic systems manufacturing has shifted overseas, so have many downstream customers and partner manufacturers. U.S. PCB manufacturers have been facing a diminishing domestic market while simultaneously finding it challenging to compete in foreign markets.

• As mass PCB production has shifted away from the U.S. towards Asia, so has the industry supply chain.
  ➢ Many specialty PCB supply chain manufacturers derive their revenue from the square feet of board produced rather than from the value of the finished PCB. This has resulted in many suppliers following PCB production overseas.
  ➢ Also, many in the supply chain have failed or merged with others in order to remain financially solvent.

• Forty-five percent of BIS survey respondents stated that a reduction in U.S. companies that manufacture laminate and other circuit-board related materials has created supply problems for them.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Bare PCB Supply Chain

• The ability to trace the source and origins of PCBs and other potentially critical components is a challenge for DoD.

• Some DoD oversight and assessment of supply-chain capabilities is needed. Other USG agencies as well as industry needs to participate in this effort.

• Potential Actions:
  - Work with DMEA (program manager for DoD Trusted Foundry program) on trusted supplier accreditation.
  - Package PCBs with Integrated Circuits into existing DMEA program and ongoing National Security Council semiconductors effort.
Materials - Bare PCB Material Sourcing

Facilities Reporting One or More Suppliers (2015)

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drill bits</td>
<td>193</td>
</tr>
<tr>
<td>Solder mask</td>
<td>193</td>
</tr>
<tr>
<td>Etchant</td>
<td>190</td>
</tr>
<tr>
<td>Laminate - rigid conventional boards</td>
<td>187</td>
</tr>
<tr>
<td>Electrolytic plating material</td>
<td>181</td>
</tr>
<tr>
<td>Copper foil</td>
<td>178</td>
</tr>
<tr>
<td>Laminate - rigid multilayer boards</td>
<td>173</td>
</tr>
<tr>
<td>Solder</td>
<td>164</td>
</tr>
<tr>
<td>Through-hole and plating preparation for plating material</td>
<td>163</td>
</tr>
<tr>
<td>Laminate - rigid high speed, high frequency, and microwave boards</td>
<td>153</td>
</tr>
<tr>
<td>Finish materials</td>
<td>149</td>
</tr>
<tr>
<td>Via fill, conductive, and non-conductive material</td>
<td></td>
</tr>
<tr>
<td>Laminate - flex boards</td>
<td>135</td>
</tr>
<tr>
<td>Laminate - rigid-flex boards</td>
<td></td>
</tr>
<tr>
<td>Embedded passives, formed, resistors, and capacitors - tin-lead</td>
<td>102</td>
</tr>
<tr>
<td>Other foils</td>
<td>88</td>
</tr>
<tr>
<td>Embedded passives, formed, resistors, and capacitors - lead-free</td>
<td>40</td>
</tr>
<tr>
<td>Other</td>
<td>35</td>
</tr>
<tr>
<td>Other</td>
<td>29</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Materials - Bare PCB Material Sourcing

Average Number of Suppliers Reported by Facility (2015)

- Laminate - rigid multilayer boards: 3.5
- Laminate - rigid conventional boards: 3.4
- Laminate - rigid-flex boards: 3.2
- Laminate - rigid high speed, high frequency, and microwave boards: 2.9
- Finish materials: 2.3
- Embedded passives, formed, resistors, and capacitors - lead-free: 2.1
- Embedded passives, formed, resistors, and capacitors - tin-lead: 2.1
- Laminate - flex boards: 1.8
- Via fill, conductive, and non-conductive material: 1.7
- Other foils: 1.7
- Copper foil: 1.7
- Other: 1.6
- Drill bits: 1.6
- Solder mask: 1.5
- Electrolytic plating material: 1.5
- Through-hole and plating preparation for plating material: 1.4
- Solder: 1.3
- Etchant: 1.2

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Materials - Bare PCB Material Sourcing

Facilities Reporting Material Availability is a Concern (2015)

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminate - rigid high speed, high frequency, and microwave boards</td>
<td>39</td>
</tr>
<tr>
<td>Laminate - rigid multilayer boards</td>
<td>22</td>
</tr>
<tr>
<td>Laminate - rigid conventional boards</td>
<td>22</td>
</tr>
<tr>
<td>Laminate - flex boards</td>
<td>20</td>
</tr>
<tr>
<td>Laminate - rigid-flex boards</td>
<td>19</td>
</tr>
<tr>
<td>Copper foil</td>
<td>16</td>
</tr>
<tr>
<td>Through-hole and plating preparation for plating material</td>
<td>15</td>
</tr>
<tr>
<td>Etchant</td>
<td>14</td>
</tr>
<tr>
<td>Solder mask</td>
<td>11</td>
</tr>
<tr>
<td>Electrolytic plating material</td>
<td>11</td>
</tr>
<tr>
<td>Via fill, conductive, and non-conductive material</td>
<td>10</td>
</tr>
<tr>
<td>Finish materials</td>
<td>9</td>
</tr>
<tr>
<td>Solder</td>
<td>6</td>
</tr>
<tr>
<td>Embedded passives, formed, resistors, and capacitors - lead-free</td>
<td>6</td>
</tr>
<tr>
<td>Embedded passives, formed, resistors, and capacitors - tin-lead</td>
<td>6</td>
</tr>
<tr>
<td>Other foils</td>
<td>6</td>
</tr>
<tr>
<td>Drill bits</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Materials - Supply Chain Disruptions Since 2012

Facilities That Experienced Supply Chain Disruptions (2012 to 2015)

- Laminate - rigid conventional boards: 40 facilities
- Laminate - rigid high speed, high frequency, and microwave boards: 38 facilities
- Laminate - rigid multilayer boards: 33 facilities
- Copper foil: 21 facilities
- Laminate - rigid-flex boards: 16 facilities
- Laminate - flex boards: 16 facilities
- Through-hole and plating preparation for plating material: 14 facilities
- Etchant: 10 facilities
- Finish materials: 9 facilities
- Electrolytic plating material: 9 facilities
- Via fill, conductive, and non-conductive material: 8 facilities
- Drill bits: 7 facilities
- Solder mask: 7 facilities
- Solder: 6 facilities
- Other foils: 5 facilities
- Embedded passives, formed, resistors, and capacitors - tin-lead: 4 facilities
- Embedded passives, formed, resistors, and capacitors - lead-free: 3 facilities
- Other: 1 facility

Source: U.S. Department of Commerce, Bureau of Industry and Security
202 respondents
Materials - Supply Chain Disruptions - Example

Does a reduction in U.S.-based companies that manufacture laminates and other circuit board-related materials create supply problems for this facility?

77% reported defense-related sales

199 respondents

Top Experienced Material Supply Chain Disruptions (2012 to 2015)

- Laminate - rigid conventional boards: 40
- Laminate - rigid high speed, high frequency, and microwave boards: 38
- Laminate - rigid multilayer boards: 33
- Copper foil: 21
- Laminate - rigid-flex boards: 16
- Laminate - flex boards: 16

Suppliers Listed – Countries:
Laminate – rigid conventional board

- United States: 56%
- China: 34%
- Taiwan: 7%
- Japan: 2%
- South Korea (ROK): 1%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Materials - Laminate for Use in Rigid Conventional Boards

- Facilities Reporting 1+ Suppliers: 187
- Availability is a Concern: 22
- Experienced Supply Chain Problems since 2012: 40
- Both: 20

Suppliers:
- Total Suppliers Reported: 627
- Suppliers Listed: 356
- Unique Suppliers Listed: 41

Suppliers Listed - Countries:
- United States: 56%
- China: 34%
- Taiwan: 7%
- Japan: 2%
- South Korea (ROK): 1%

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Materials - Laminate for Use in Rigid Multilayer Boards

- Facilities Reporting 1+ Suppliers: 173
- Availability is a Concern: 21
- Experienced Supply Chain Problems since 2012: 33
- Both: 20

Total Suppliers Reported: 600
Suppliers Listed: 323
Unique Suppliers Listed: 32

Suppliers Listed - Countries
- United States: 62%
- China: 29%
- Taiwan: 7%
- Japan: 2%
- South Korea (ROK): <1%
- Other: 20%
Materials - Laminate for use in Rigid High Speed, High Frequency, and Microwave Boards

- **Number of Facilities Reporting 1+ Suppliers:** 153
- **Availability is a Concern:** 39
- **Experienced Supply Chain Problems since 2012:** 38
- **Both:** 29

**Suppliers Listed - Countries**
- United States: 85%
- Japan: 7%
- China: 6%
- Taiwan: 2%
- South Korea (ROK): <1%

**Number of Suppliers**
- Total Suppliers Reported: 450
- Suppliers Listed: 273
- Unique Suppliers Listed: 27

**Source:** U.S. Department of Commerce, Bureau of Industry and Security

*202 respondents*
Materials - Impact of Supply Chain Disruptions

If this facility were no longer able to purchase circuit board laminate from your current suppliers, for how many weeks could you continue normal operations?

<table>
<thead>
<tr>
<th>Number of Facilities</th>
<th>0 weeks</th>
<th>1-4 weeks</th>
<th>5-12 weeks</th>
<th>13-26 weeks</th>
<th>27-52 weeks</th>
<th>52+ weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>149</td>
<td>40</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

How many weeks would it take this facility to obtain material from a new supplier of laminate?

<table>
<thead>
<tr>
<th>Number of Facilities</th>
<th>0 weeks</th>
<th>1-4 weeks</th>
<th>5-12 weeks</th>
<th>13-26 weeks</th>
<th>27-52 weeks</th>
<th>52+ weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td></td>
<td>164</td>
<td></td>
<td>28</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
Materials - Impact of Supply Chain Disruptions

Does a reduction in U.S.-based companies that manufacture laminates and other circuit board-related materials create supply problems for this facility?

- Yes: 90 facilities
- No: 109 facilities

77% reported defense-related sales

How confident are you that this facility could obtain the materials necessary to rapidly ramp up production in a national emergency?

- Very Confident: 86 facilities
- Somewhat Confident: 68 facilities
- Not Confident: 37 facilities
- Would Not Be Able To: 8 facilities
- N/A: 3 facilities

Q6b,A3/A4

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

199 respondents
Materials - Inventory Practices for Bare PCB Production Materials

Which statement best describes this facility's general method for maintaining inventory levels of laminate and related materials required for the production of circuit boards?

- Maintain extra inventory as a buffer against unexpected delays in material shipments and unanticipated new production orders: 106 facilities (52%)
- Minimize on-hand inventory of circuit board production materials: 93 facilities (46%)
- N/A, 3, 2%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Materials - Practices Used to Assure Availability of Bare PCB Materials

- On-site stocking agreements through which distributors/manufacturers keep a quantity of materials at this facility.
- Local stocking agreements through which distributors/manufacturers maintain supply warehouses in close proximity to this facility.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q6b,C

202 respondents
Equipment – Number of Functioning Units On Site

- Drilling - mechanical: 1161
- Electrical testing: 633
- Routing: 630
- Quality control measurement: 530
- Photo resist exposure: 510
- Electrolytic copper: 467
- Photo resist application: 464
- Lamination: 443
- Final finish: 436
- Develop etch & strip equipment: 340
- Solder mask: 337
- Automatic optical inspection: 328
- Chemical cleaning: 287
- Legend print: 286
- Photo film processing: 227
- Inner layer treatment & layup: 202
- Desmear: 196
- Scoring: 178
- Electroless copper: 167
- Photo resist exposure-laser: 143
- Drilling - laser: 140
- Via fill: 125
- Photo resist exposure-LED: 29

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Equipment – Number of Facilities With Functioning Units On Site

1. Drilling - mechanical: 200
2. Photo resist application: 197
3. Routing: 195
4. Develop etch & strip equipment: 195
5. Photo resist exposure: 193
6. Lamination: 189
7. Solder mask: 184
8. Electrical testing: 181
9. Electrolytic copper: 180
10. Photo film processing: 180
11. Legend print: 179
12. Chemical cleaning: 176
13. Final finish: 172
14. Quality control measurement: 168
15. Inner layer treatment & layup: 163
16. Electroless copper: 159
17. Desmear: 159
18. Automatic optical inspection: 147
19. Scoring: 141
20. Via fill: 90
21. Photo resist exposure-laser: 74
22. Drilling - laser: 63
23. Photo resist exposure-LED: 22

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Equipment – Average Age of Functioning On Site Units

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q6c,A

202 respondents
Equipment – Primary Concerns

Aggregated U.S. Bare PCB Facility Responses – Primary Concerns About Continued/Future Use of On Site Equipment

- Cost to replace (1305 responses)
  - None (720 responses)
  - Spare parts (312 responses)
  - Service (294 responses)
  - Skill to operate (213 responses)
  - Time to replace (200 responses)
  - Upgradeability (142 responses)
  - Other (105 responses)
  - Availability (77 responses)

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Equipment - Trouble Obtaining Parts and Service

Has this facility had trouble obtaining PARTS for U.S. or non-U.S. equipment?

<table>
<thead>
<tr>
<th></th>
<th>U.S. Equipment</th>
<th>Non-U.S. Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>84</td>
<td>113</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>N/A</td>
<td>112</td>
<td>32</td>
</tr>
</tbody>
</table>

Has this facility had trouble obtaining SERVICE on U.S. or non-U.S. equipment?

<table>
<thead>
<tr>
<th></th>
<th>U.S. Equipment</th>
<th>Non-U.S. Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>86</td>
</tr>
<tr>
<td>N/A</td>
<td>35</td>
<td>35</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q6c, B

202 respondents
Are there bare circuit board products that this facility is unable to manufacture due to the limitations of installed equipment?

- Large >$40M
- Medium $10M-$40M
- Small <$10M

Number of Facilities

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>115</td>
<td>86</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

201 respondents
Equipment – New Equipment Supply Concerns for Tin-Lead Bare PCBs

Have you had or do you anticipate having difficulty obtaining new equipment for manufacturing tin-lead bare circuit boards?

<table>
<thead>
<tr>
<th></th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>35</td>
</tr>
<tr>
<td>No</td>
<td>148</td>
</tr>
<tr>
<td>N/A</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Materials - Suspected/Confirmed Counterfeit Materials

Between 2012 and 2015, did this facility encounter product failures that are suspected or confirmed to be attributed to counterfeit materials used in building bare circuit boards?

Material - Prepreg

- "Prepreg would not melt to join the inner layers together on three separate occasions."
- "We had a batch from [a company] that kept delaminating now we only use [different company product] for standard runs."
- "When Non-U.S. raw material manufacturers make changes in the material, they do not feel obligated to notify us."
- "Don't use"
- "Purchase from OEM"

122

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
Materials - Suspected/Confirmed Counterfeit Materials

Between 2012 and 2015, did this facility encounter product failures that are suspected or confirmed to be attributed to counterfeit materials used in building bare circuit boards?

Material - Laminate

- **Confirmed**: 2 facilities
- **Suspected**: 4 facilities
- **Both**: 2 facilities
- **No**: 72 facilities
- **N/A**: 122 facilities

*“Unknown Chinese manufacturing using our [redacted] logo.”*

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
Materials - Suspected/Confirmed Counterfeit Materials

Between 2012 and 2015, did this facility encounter product failures that are suspected or confirmed to be attributed to counterfeit materials used in building bare circuit boards?

Material - Soldermask

<table>
<thead>
<tr>
<th></th>
<th>Confirmed</th>
<th>Suspected</th>
<th>Both</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>77</td>
<td>121</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Materials – Bare PCB Materials Procurement

Does this facility buy materials for the manufacture of bare circuit boards from sources other than the original manufacturer or its authorized distributor?

If so, what practices do you regularly use to verify that the materials are genuine and perform to specifications?

- Confirm production lots and production dates with the original manufacturer: 14 facilities
- Check authenticity of standards organization certification labels/trademarks: 12 facilities
- Systematic testing of inventory: 10 facilities
- Other: Purchase material through USA auctions and are able to identify most material: 1 facility
- Certificate required from the manufacturer of material: 1 facility

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
CHAPTER 6:
SALES

- AGGREGATE COMPANY AND FACILITY SALES
- DOMESTIC SALES AND EXPORTS
- GOVERNMENT SALES
Sales (2012-2015)

- Respondents reported their total sales by facility, all circuit-board-related sales (including design, manufacture, and assembly), and Bare circuit board manufacturing sales (excluding design and assembly) for the period of 2012 to 2015. They also reported figures for both U.S. and non-U.S. sales. Additionally, respondents provided the percent of Government sales for each of the above categories.

- Bare PCBs constituted 83 percent of total sales during the four year period from 2012 to 2015. All CB sales constituted 97 percent of total sales during the four year period from 2012 to 2015.

- During the period of 2012 to 2015, five large companies out of 185 total accounted for 43 percent of total industry bare PCB sales.

- Industry Bare PCB sales for the 2012 to 2015 period were relatively flat. Bare PCB manufacturing sales increased 1.5 percent for the period from 2012 to 2015. Large companies were responsible for 110 percent of total Bare PCB sales growth from 2012 to 2015.
  - 21 facilities showed sales growth every year during the 2012 to 2015 period.
  - 36 facilities showed sales decline every year during the 2012 to 2015 period.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Sales (2012-2015)

- During the period of 2012 to 2015, U.S. Bare PCB domestic sales averaged 85 percent compared to 15 percent for exports sales.
  - U.S. domestic sales increased by 3.8 percent from 2012 to 2015
  - U.S. Bare PCB exports decreased by 13 percent from 2012 to 2015

- From 2012 to 2015, large companies accounted for 39 percent, medium for 37 percent, and small-sized for 24 percent of domestic Bare PCB sales. During the same period, large companies accounted for 64 percent, medium for 29 percent, and small-sized for 7 percent of Bare PCB export sales.

- From 2012 to 2015, U.S. sales growth for Bare PCBs was driven by large and medium-sized companies which were responsible for 66 percent and 43 percent of growth, respectively. Small-sized companies were the only category to report an increase in exports sales from 2012 to 2015, from $17M to $25M. However, total exports decreased 13 percent, from $306M to $266M during the same period.

- U.S. Government sales increased each year, from $386M in 2012 to $453M in 2015. Medium-sized enterprises accounted for $48M, or 71 percent of the USG sales increase from 2012 to 2015.

Source: U.S. Department of Commerce, Bureau of Industry and Security
Bare PCB Sales (2015)

Bare PCB Sales by Company Size – Total $2.03 Billion in 2015

- Small < $10M
- Medium $10M-$40M
- Large > $40M

- 10 Publicly Traded
- 175 Privately Held

$875 Million 142 Small

$432 Million 5 Large

$722 Million 38 Medium

Source: U.S. Department of Commerce, Bureau of Industry and Security

185 respondents
### Total Sales, All CB-Related Sales, Bare PCB Sales (2012-2015)

#### U.S. Bare PCB Manufacturers

- **Total Sales**
  - 2012: $2.39
  - 2013: $2.46
  - 2014: $2.49
  - 2015: $2.47

- **All CB Sales**
  - 2012: $2.31
  - 2013: $2.43
  - 2014: $2.43
  - 2015: $2.37

- **Bare PCB Manufacturing Sales**
  - 2012: $2.00
  - 2013: $2.06
  - 2014: $2.04
  - 2015: $2.03

**Source:** U.S. Department of Commerce, Bureau of Industry and Security

202 respondents

Q7

- All CB sales constituted 97 percent of total sales during the four year period from 2012 to 2015.
- Bare PCBs constituted 83 percent of total sales during the four year period from 2012 to 2015.
### Breakout of Industry Sales (2012-2015)

#### Total Sales, All CB Sales, and Bare CB Sales

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U.S.</td>
<td>Non-U.S.</td>
<td>U.S.</td>
<td>Non-U.S.</td>
</tr>
<tr>
<td><strong>Total Sales (in $)</strong></td>
<td>$ 1,946</td>
<td>$ 441</td>
<td>$ 2,030</td>
<td>$ 434</td>
</tr>
<tr>
<td><strong>Total Government Sales</strong></td>
<td>$ 470</td>
<td>$ 6</td>
<td>$ 530</td>
<td>$ 6</td>
</tr>
<tr>
<td><strong>All Circuit Board-Related Sales - including design, manufacture, and assembly (in $)</strong></td>
<td>$ 1,885</td>
<td>$ 428</td>
<td>$ 2,000</td>
<td>$ 429</td>
</tr>
<tr>
<td><strong>All Circuit Board-Related Government Sales</strong></td>
<td>$ 460</td>
<td>$ 6</td>
<td>$ 513</td>
<td>$ 6</td>
</tr>
<tr>
<td><strong>Bare Circuit Board Manufacturing Sales - excluding design and assembly (in $)</strong></td>
<td>$ 1,698</td>
<td>$ 306</td>
<td>$ 1,731</td>
<td>$ 332</td>
</tr>
<tr>
<td><strong>Bare Circuit Board Government Sales</strong></td>
<td>$ 386</td>
<td>$ 5</td>
<td>$ 408</td>
<td>$ 6</td>
</tr>
</tbody>
</table>
Bare PCB Sales – by Facility Size (2012-2015)

2012
- Small <$10M
- Medium $10M-$40M
- Large >$40M

$659M
$450M
$895M

2013
- Small <$10M
- Medium $10M-$40M
- Large >$40M

$676M
$452M
$936M

2014
- Small <$10M
- Medium $10M-$40M
- Large >$40M

$680M
$455M
$907M

2015
- Small <$10M
- Medium $10M-$40M
- Large >$40M

$693M
$451M
$885M

Small: Under $10M in annual sales
Medium: $10M-$40M in annual sales
Large: Over $40M in annual sales

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Distribution of Bare PCB Sales by Facility (2015)

21 facilities reported sales growth every year during the 2012 to 2015 period.
- Average sales growth of 68 percent (2012-2015).
- Average yearly sales growth of 18 percent.

36 facilities reported sales decline every year during the 2012 to 2015 period.
- Average sales decline of 32 percent (2012-2015).
- Average yearly sales decline of 13 percent.
Bare PCB Sales (2012-2015) – By Facility Size

Large facilities were responsible for 135 percent of total Bare PCB sales growth from 2012 to 2015.

- **Large** facilities: 5.2% growth
- **Medium** facilities: -1.1% growth
- **Small** facilities: 0.2% growth

### Bare PCB Sales (2012-2015) – By Facility Size

**$ Millions**

- **2012**
  - Small <$10M: $450
  - Medium $10M-$40M: $452
  - Large >$40M: $895
- **2013**
  - Small <$10M: $452
  - Medium $10M-$40M: $452
  - Large >$40M: $936
- **2014**
  - Small <$10M: $455
  - Medium $10M-$40M: $455
  - Large >$40M: $907
- **2015**
  - Small <$10M: $451
  - Medium $10M-$40M: $451
  - Large >$40M: $885

Source: U.S. Department of Commerce, Bureau of Industry and Security

**Q7**

202 respondents
**Bare PCB Sales (2012-2015) – By Company Size**

Large companies were responsible for 110 percent of total Bare PCB sales growth from 2012 to 2015.

- **Large**: $880 million in 2015, $726 million in 2014, $877 million in 2013, $847 million in 2012
- **Medium**: $753 million in 2015, $722 million in 2014, $753 million in 2013, $727 million in 2012
- **Small**: $436 million in 2015, $432 million in 2014, $436 million in 2013, $430 million in 2012

**Bare PCB Sales Growth (2012-2015):**
- Large: 3.3%
- Medium: -0.7%
- Small: 0.5%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

185 respondents
Bare PCB Sales (2012-2015) – Large Companies

During the period of 2012 to 2015, five large companies out of 185 total accounted for 43 percent of total industry Bare PCB sales.

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
During the period of 2012 to 2015 U.S. Bare PCB sales averaged 85 percent compared to 15 percent for exports sales.

From 2012 to 2015:
- U.S. domestic sales increased by 3.8 percent
- Exports decreased by 13 percent
Bare PCB Company Sales (2012-2015)  
U.S. and Exports

Bare PCB Sales by Company Size (2012-2015)

Source: U.S. Department of Commerce, Bureau of Industry and Security  
U.S. Bare Printed Circuit Board Industry Assessment – 2017

185 respondents
Bare PCB Sales by Facility Size (2012-2015)

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Bare PCB Company Sales (2012-2015)  
U.S. and Exports

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Large &gt;$40M</td>
<td>6.6%</td>
<td>-7.7%</td>
</tr>
<tr>
<td>Medium $10M-$40M</td>
<td>4.4%</td>
<td>-34.4%</td>
</tr>
<tr>
<td>Small &lt;$10M</td>
<td>-1.5%</td>
<td>47.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Large &gt;$40M</td>
<td>10.4%</td>
<td>-7.9%</td>
</tr>
<tr>
<td>Medium $10M-$40M</td>
<td>2.9%</td>
<td>-33%</td>
</tr>
<tr>
<td>Small &lt;$10M</td>
<td>-1.6%</td>
<td>47%</td>
</tr>
</tbody>
</table>

- From 2012 to 2015, U.S. sales growth for Bare PCBs was driven by large and medium-sized companies which were responsible for 66 percent and 43 percent of growth, respectively.

- Small-sized companies were the only category to report an increase in exports sales from 2012 to 2015, from $17M to $25M. However, total exports decreased 13 percent, from $306M to $266M during the same period.
Bare PCB Sales (2012-2015)
Government vs. Non-Government Sales

- Government sales accounted for 21 percent of total Bare PCB sales during the 2012 to 2015 period.

Bare PCB Sales by U.S. Facilities (2012-2015)

- U.S. Government sales accounted for 99 percent of total Government sales during the 2012 to 2015 period.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
USG sales increased each year, from $386M in 2012 to $453M in 2015.
- 5.5 Percent average increase year to year.
- 17 percent total increase (2012 to 2015).

USG sales increase (2012-2015)
- Large: 14 percent
- Medium: 22 percent
- Small: 14 percent

Medium-sized enterprises accounted for $48M, or 71 percent of the USG sales increase from 2012 to 2015.
- Large facilities accounted for $14M, or 21 percent of USG sales increase (2012 to 2015).
- Small facilities accounted for $5M, or 8 percent of USG sales increase (2012 to 2015).
CHAPTER 7: FINANCIALS

- FINANCIAL RISK RATINGS
- NEGATIVE NET INCOME AND FACILITIES OPERATING AT A LOSS
- NET PROFIT MARGIN
- NET SALES PER EMPLOYEE
- DEBT RATIO
Financials (2012-2015)

BIS survey respondents provided data on select financial accounting items, including net and operating income, assets, liabilities, and inventories.

BIS used this financial data to calculate certain financial ratios, profitability, and other metrics. Additionally, BIS developed a customized financial risk metric to better capture the overall financial condition of respondents. The model was based largely on standardized financial ratios covering profitability, liquidity, leverage, and default probability of an organization over time. Additional select qualitative data were taken into account during the financial risk evaluation.

Respondents were assigned a comprehensive 2012-2015 financial risk score, which incorporated yearly scores and trends in financial health. Based on this scorecard, respondents were categorized as low/neutral risk, moderate/elevated risk, or high/severe risk. Some respondents did not have data for all years or all measures and as a result could not be assigned a financial risk score. These respondents are included in the uncalculated risk category.

Respondents were assigned a comprehensive 2012-2015 financial risk score, which incorporated yearly scores and trends in financial health. Based on this scorecard, respondents were categorized as low/neutral risk, moderate/elevated risk, or high/severe risk. Some respondents did not have data for all years or all measures and as a result could not be assigned a financial risk score. These respondents are included in the uncalculated risk category.
Financials


Financial Risk Rating – Facility Size

<table>
<thead>
<tr>
<th>Financial Risk Rating</th>
<th>Large &gt;$40M</th>
<th>Medium $10M-$40M</th>
<th>Small &lt;$10M</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe Risk</td>
<td>4</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Low/Neutral Risk</td>
<td>36</td>
<td>37</td>
<td>7</td>
</tr>
<tr>
<td>Moderate/Elevated Risk</td>
<td>11</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Uncalculated</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Financial Risk Rating – Facilities with Defense-Related Production

<table>
<thead>
<tr>
<th>Financial Risk Rating</th>
<th>Large &gt;$40M</th>
<th>Medium $10M-$40M</th>
<th>Small &lt;$10M</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe Risk</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Low/Neutral Risk</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Moderate/Elevated Risk</td>
<td>24</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>Uncalculated</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

202 respondents

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

### Financial Risk Rating

**Facility Size**

- Only 5 out of 202 Bare PCB manufacturing facilities received a High/Severe financial risk score

### Financial Risk Rating

**Facilities with Defense-Related Bare PCB Production**

- 4 out of the 5 Bare PCB manufacturing facilities that received a High/Severe financial risk score reported some level of defense-related production

<table>
<thead>
<tr>
<th>Facility Financial Risk Score</th>
<th>Large &gt;$40M</th>
<th>Medium $10M-$40M</th>
<th>Small &lt;$10M</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe Risk</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Low/Neutral Risk</td>
<td>6</td>
<td>36</td>
<td>94</td>
<td>136</td>
</tr>
<tr>
<td>Moderate/Elevated Risk</td>
<td>3</td>
<td>7</td>
<td>37</td>
<td>47</td>
</tr>
<tr>
<td>Uncalculated</td>
<td>1</td>
<td>2</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>46</strong></td>
<td><strong>146</strong></td>
<td><strong>202</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Financial Risk Score</th>
<th>Large &gt;$40M</th>
<th>Medium $10M-$40M</th>
<th>Small &lt;$10M</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe Risk</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Low/Neutral Risk</td>
<td>6</td>
<td>34</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Moderate/Elevated Risk</td>
<td>3</td>
<td>6</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>Uncalculated</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>43</strong></td>
<td><strong>92</strong></td>
<td><strong>145</strong></td>
</tr>
</tbody>
</table>
Financials

Financial Risk Rating – Large Facilities (10)
- High/Severe Risk: 1, 10%
- Low/Neutral Risk: 3, 30%
- Moderate/Elevated Risk: 6, 60%
- Uncalculated

Financial Risk Rating – Medium Facilities (46)
- High/Severe Risk: 2, 5%
- Low/Neutral Risk: 7, 15%
- Moderate/Elevated Risk: 36, 78%
- Uncalculated

Financial Risk Rating – Small Facilities (146)
- High/Severe Risk: 11, 8%
- Low/Neutral Risk: 37, 25%
- Moderate/Elevated Risk: 94, 64%
- Uncalculated

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Financials

Negative Net Income (2012-2015)

Facilities Reporting Negative Net Income (2012-2015)

- Large >$40M
- Medium $10M-$40M
- Small <$10M

An average of 65 facilities per year, or 32 percent of survey respondents, reported negative net income from 2012 to 2015.

22 facilities reported negative net income for all four years from 2012 to 2015.

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
Financials
Facilities Operating at Net Loss (2012-2015)

- 22 facilities reported negative net income every year from 2012 to 2015
  - 8 reported dependency on the USG for their continued viability
  - 4 have defense-related sales of 50% or more
  - 5 reported supporting 20 or more USG programs

Financial Risk Rating

- High/Severe Risk: 4
- Moderate/Elevated Risk: 4
- Low/Neutral Risk: 13
- Uncalculated: 1

Changes Expected 2016-2020

- Potential Closure: 4
- Contraction: 4
- Modernization: 9
- Expansion: 1
- None/Other: 1

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

22 respondents
Financials
Net Profit Margin (2012-2015)

Net Profit Margin by Facility Size

While all but one large facilities reported lower net profit in 2013, two facilities accounted for the majority of the decline in profitability among large facilities in 2013.

The average profit margin for all respondents from 2012 to 2015 was 2.7 percent.

Large – 6.6 percent
Medium – 5.3 percent
Small – 1.6 percent

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
Financials
Sales per Employee (2012-2015)

Average Annual Net Sales per Employee by Respondent Size

Average net sales per employee increased 8.9 percent from 2012 to 2015. The increase was highest among large facilities at 12.2 percent, followed by medium facilities at 8 percent, and small facilities at 6.3 percent.
Debt Ratio (2012-2015)

Debt Ratio by Facility Size

Debt Ratio is a financial ratio that measures the extent of a company’s leverage, or the percentage of a company’s assets relative to debt.

\[ \text{Debt Ratio} = \frac{\text{Total Liabilities}}{\text{Total Assets}} \]

Respondent debt ratios were calculated using financial data provided in the BIS industry survey. The figures in this chart represent the average of all individual respondent debt ratios calculated.

Source: U.S. Department of Commerce, Bureau of Industry and Security

167 respondents

Q8
CHAPTER 8: RESEARCH AND DEVELOPMENT (R&D) AND CAPITAL EXPENDITURES (CAPEX)

• NEED FOR R&D AND CAPITAL INVESTMENT (CAPEX)
• R&D
  ➢ R&D EXPENDITURES AND FUNDING SOURCES (2012-2015)
  ➢ TOP PRIORITIES AND INVESTMENT FACTORS
  ➢ DEPARTMENT OF DEFENSE (DOD) IMPACT AND SUPPORT
• CAPEX
  ➢ CAPITAL EXPENDITURES (2012-2015)
  ➢ EFFECT OF U.S. GOVERNMENT SPENDING CUTBACKS
  ➢ TOP PRIORITIES (2016-2020)
Need for R&D and Capital Investment (CAPEX)

- PCB manufacturing is a process that is both capital and technology-intensive.
- Technology and processes advance rapidly, driving the need for new equipment.
- Manufacturers need to add to or update techniques and equipment regularly to remain globally competitive.
- Cost of equipment and innovation has resulted in a gap between large and small manufacturers.

Reported Average Net Profit Margin (2012-2015):
- Large - 6.7%
- Medium - 5.3%
- Small - 1.6%

Reported Average Net Sales per Employee (2012-2015):
- Large – $3.53M
- Medium - $2.12M
- Small - $153K

Bare PCB CAPEX as a percentage of 2015 sales:
- Large – 2.1%
- Medium – 4.1%
- Small – 6.2%

Only 38 out of 185 companies reported conducting R&D:
- Large - 4 (80%)
- Medium - 14 (39%)
- Small - 20 (13%)

Source: U.S. Department of Commerce, Bureau of Industry and Security
'U.S. Bare Printed Circuit Board Industry Assessment – 2017
Need for R&D and Capital Investment (CAPEX)

There is a notable difference in investment in continuous technology innovation between smaller and larger U.S. PCB manufacturers.

Why this is a problem for small-scale PCB enterprises:

- Lack of sufficient investment
- Ability to innovate is affected

Further limits the need for further innovation

Can become bound to a limited market

Less Innovation

Less increase in productivity

Combined with intense price competition from foreign competitors, U.S. manufacturers cannot raise prices to offset rising production costs

Less increase in productivity also puts pressure on manufacturers facing increasing labor costs and talent acquisition challenges

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Need for R&D and Capital Investment (CAPEX)

• Industry comment - “Innovation is important to meeting both legacy and future DoD needs.“

• R&D for PCBs has shifted offshore (partly due to foreign government R&D support and growth in Asian PCB manufacturing).

• U.S. PCB manufacturers, facing lower margins and lower sales volumes, are becoming limited in their investments in R&D, technology, and innovation.

  Industry Comments:
  • “The Asian market has driven the commercial market share out of the country. The small companies cannot afford the equipment needed for technology advancement.”
  • “Large portion of the US bare circuit board industry, (137 out of 202, 68%) are sub $10 million in revenue that have not been able to recapitalize and have aging ownership.”
  • “Lack of capital investments by these facilities makes them non-competitive technologically – and therefore do not have the capability to meet today’s demands.”
  • “In the U.S., only the remaining large public and private PCB companies will be able to afford the necessary capital costs for acquiring state-of-the-art equipment.”

• It is important for the U.S. PCB industry to make the investments in advanced manufacturing required in order to maintain competency and competitiveness with the global leaders in China, Taiwan, and Japan.

• Need for U.S. PCB Industry partnership and collaboration efforts (consortium) to conduct R&D?
  ➢ Possible partners – DARPA, NIST, iNEMI, Universities, others?
  ➢ Increase investments in basic technology, product R&D, and process R&D.
  ➢ Creation of tax incentives, rebates or credits for DoD suppliers of PCBs in order to renew interest and investment by U.S. PCB manufacturers.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
BIS asked survey respondents by facility whether they conducted research and development (R&D). Forty facilities (representing 38 companies) replied that they do, accounting for 20 percent of all facilities.

Of the 38 of 185 companies that reported conducting R&D:

- Large companies - 4 out of 5 (80%)
- Medium companies - 14 out of 38 (37%)
- Small companies - 20 out of 142 (13%)
Research & Development

U.S. Bare PCB Facilities R&D Expenditures (2012-2015)

*Note: R&D expenditures for one large company are not included

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

38 respondents
Research & Development
Types of Expenditures

U.S. Bare PCB Facilities Reported R&D Expenditures (2012-2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total R&amp;D Expenditures</th>
<th>Basic Research</th>
<th>Applied Research</th>
<th>Product/Process Development</th>
<th>No Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>$43,871</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>$49,243</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>$61,876</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>$62,991</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: R&D expenditures for one large company are not included
**No data refers to R&D expenditures not identified by type. Many respondents were not able to report R&D expenditures with that level of detail.

Source: U.S. Department of Commerce, Bureau of Industry and Security

38 respondents
Research and Development Funding Sources

U.S. Bare PCB Facilities R&D Funding Sources (2015)

*Note: R&D expenditures for one large company are not included

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Research and Development
Percentage of Total Sales

U.S. Bare PCB Facilities Reported R&D Expenditures as a Percentage of Total Sales (2012-2015)

*Note: R&D expenditures for one large company are not included

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

38 respondents
Research & Development
Top Priorities

Anticipated Top R&D Priorities (2016-2020)

- Other: 55 responses
- Enhanced solid copper via fill methods: 25 responses
- Development of very thin unsupported dielectrics: 18 responses
- Printed electronics (additive, 3-D, etc.): 15 responses
- Advanced embedded active/passive device methods: 15 responses
- Stretchable/wearable electronics: 14 responses
- Ultra smooth copper foil: 12 responses
- Sub-10 micrometer photoresists, etchants: 8 responses
- Direct IC die-on-board ultra high density interconnects: 7 responses

Survey respondents could list up to 5 anticipated top R&D priorities.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Research & Development - Top Priorities: ‘Other’ Comments

**OTHER:**
- Fineline etching development, .002” space/trace or less
- Focus is currently in increasing blind and buried via capability
- HDI, obtaining 1 mil lines and spaces and thin dielectrics.
- High Temp Rigid Flex
- Laser drilled microvias
- Market focus on high end application development related to Automotive and Industrial Devices
- Material Testing
- Microvias
- No R&D going forward
- Prototype product requires R&D to perfect each part/process.
- Sequential Lamination strategies and optimizations
- Work on development of flex products and nano technology
- Working on direct imaging
- Additive plating / circuit creation
- Back drill stub capability
- Development of low -Loss / RF material capabilities
- Embedded plastic circuitry
- Focus will be on developing a non-conductive via-fill capability
- Heavy copper builds using plating and lamination.
- High Density semiconductor packaging, including use of glass interposers
- High speed flex circuitry >12Gbps
- long thin flex for medical catheter products
- new high speed materials and technologies required to manufacture
- RF Rigid Flex
- Stacked/staggered via configurations
- 50 micron lines/spacing
- alternate interconnect methods, no vias, conductive pastes
- Backdrilling implementation
- Blind/Buried via capability
- Connectorization on automatic RF connectors
- Fine lines and spaces down to .001
- Greater capability to model thermal solutions for flex heater products
- Laser cutting of polyimide coverlay materials
- Extra Large Form-Factor for RF Antennas
- HDI
- Improve Flex / Rigid-Flex capabilities
- Novel electrical interconnect methods for high end (high layer count, high density ) printed
- Speed and efficiency improvements & yield improvement on HDI boards.
- Sub 25 micron circuits
- High performance (speed) printed wiring boards using ultra-low loss dielectrics and smooth copper
- High speed/low loss designs and hybrid construction will increase.
- Routing and scoring of rigid boards

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
**Research & Development - Top Priorities: Comments**

- Copper fill and high aspect ratio needs
- Reduce cycle-time, expand aspect ratio capability
- Need to continue to refine this process and improve throughput.
- Plan to add metal and epoxy via fill capabilities
- Copper via fill is demanded in today’s market and will continue into the future.
- Currently process is very time consuming
- High Density Interconnect (HDI) package test applications
- Close vias at plating or other additive material to allow capping or preclude it’s need
- Required in many sequential lamination strategies
- LCP
- 2 mil cores and lower
- HDI packaging
- For all flexible circuit applications, especially medical devices, including implantable.
- IRAD driving thin flexible interposers fabrication and die assembly
- Need to improve signal loss
- Looking into wireless devices
- Seeing more demand for these technologies.
- Drives package and overall system shrink
- Specifically whether or not to etch our own resistors
- Reduce foot print
- Passive integration to support density

---

**Printed electronics (additive, 3-D, etc.)**

- eSurface process.
- Identify materials that can print on polyimide film
- Heaters
- Future methods of manufacturing, new technology
- Addition of metal and epoxy via fill capabilities
- Flex and rigid-flex product
- Flex circuits is an area to investigate
- Prototypes
- Stacked/staggered via configurations
- RF demand to improve circuit loss
- High speed designs

---

**Stretchable/wearable electronics**

- Full circuit is an area to investigate

---

**Ultra smooth copper foil**

- 2 mil cores and lower
- Sub-10 micrometer photoresists, etchants

---

**Direct IC die-on-board ultra high density interconnects**

- Working with [redacted] for special dry film resist and etching needs
- Higher density product will continue to grow requiring advancements in capability.
Research & Development
Investment Factors

Key Factors Driving R&D Investment (2015)

- Need for competitive advantage: Yes 49, No 7, N/A 146
- Customer requirements: Yes 49, No 6, N/A 147
- Industry roadmap: Yes 34, No 12, N/A 156
- Other: Yes 0, No 3, N/A 199

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017


**Need for competitive advantage:**

- “Maintaining competitive edge is always a concern with foreign competition”
- “Competing globally”
- “Contract manufacturers for semiconductor packaging are continuing to increase packaging density to accommodate the continually shrinking nodes for IC manufacturers and increasing signal processing speeds for semiconductor packaging and printed wiring boards. Must accommodate the OEMs’ needs for faster data processing”
- “Product differentiator”
- “Direct Image will be used for a sales tool also”
- “To continue sustained growth R&D is required”
- “Increasing capabilities promotes additional business”
- “Need to keep focusing on niche opportunities, steer away from the U.S. price erosion market”
- “Need to stay on high end of technology curve”
- “Reduce cost, improve yields and capabilities”
- “System level competitive advantage”
- “Trying to separate ourselves from local competitors and their standard capabilities”
Research & Development
Key Factors Driving Investment: Industry Comments

Customer Requirements:

- “Advances in semiconductor performance and corresponding test applications”
- “Attempt to lock in with customers that need our specialized services”
- “Customer asking for direct imaging”
- “Customers are demanding more complex builds, more dense PCBs”
- “Customers continually drive new products, technology”
- “Customers requesting quick turn for evaluation”
- “Designs are getting smaller with more spacing constraints”
- “Development for specific high-end applications”
- “Higher temp, higher frequency, higher speed in harsher environments”
- “Increase packaging density and signal processing speeds”
- “Market demand always drives needed capability”
- “Need to maintain and grow market share with key customers”
- “Our customers have needs now for both ultra fine lines and heavy copper”
- “Reacting to customer requirements helps promote growth activities”
**Research & Development**

**Key Factors Driving Investment: Industry Comments**

**Industry roadmap:**

- “Again based on market demand”
- “All of our competitors have Direct Image”
- “High speed (> 20 gig performance PCI application in semiconductor)”
- “Keeping up with and exceeding industry expectations promotes relevance with customers”
- “Manufacturing capabilities to support customer roadmap”
- “Need to stay ahead of the curve”
- “Technology is moving towards more complicated and dense designs”
- “U.S. need to stay on high end of technology curve”

*Source: U.S. Department of Commerce, Bureau of Industry and Security*

*202 respondents*
Research & Development
USG Spending Reduction Impacts

From 2012-2015, were your organization's R&D expenditures adversely impacted by reductions in U.S. Government defense spending?

Yes, 14, 7%
No, 45, 22%
N/A, 143, 71%

Comments:
- “Budget cuts and price pressure have reduced sales and available resources”
- “Government support of organizations like [redacted] reduced or eliminated contract money available for funding [redacted] programs”
- “Many project that were well underway were put on hold causing a great reduction in shop loading”
- “Reduce customer demand and product development”
- “Sequester hurt us, and many others, and we are still recovering”
- “We use to do a lot more work with [redacted] locally in [redacted], but they are hardly doing anything”
- “Higher order volume and more consistent order volume would greatly improve R&D expenditures. Currently the bare board industry is in very tough financial shape, so very little true R&D takes place.”
- “With more government business, we would have theoretically spent more on R&D”

Comments:
- “Defense contracts are usually not cutting edge technology”
- “Government defense business is a relatively low percentage of our total market today”
- “Investments increased to support technology goals”
- “Research and Development is fundamental in remaining relevant in the marketplace and was not impacted by reduced government spending”

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Research & Development
Improving PCB Performance (2015)

Comments for ‘Yes’:

- “[redacted] for enhanced buried capacitance RF/video transmission”
- “Additive technologies and the integration of optics on board technologies”
- “All aspects of printed circuit fabrication from Single-sided to HDI multilayers”
- “All manufacturers are hindered by material dimensional stability and also copper via longevity after numerous temperature cycles”
- “Development work for new technologies is not readily available to most suppliers”
- “HDI manufacturing technology”
- “Material testing that support cryogenic temps currently only single source available”
- “Printed heaters”
- “RF materials, Advanced substrate development for Aerospace community. Development of advanced cooling methods”
- “Rigid-Flex capabilities, Embedded Passives”
- “Strengthen domestic sourcing of leading material and equipment base”
- “Ultra high frequency applications”
- “Ultra-low loss dielectric materials, smooth copper, optoelectronics”
- “Advanced organic microelectronic packaging could move forward more quickly with DOD funding and support”
- “Need information on how to develop things like Rigid/flex combination that we have had requests for. Need educational resources”
- “We have been working with the (redacted) technology for additive plating and circuit creation. This technology promises to vastly improve our ability to create fine lines & spaces (down to .001 and less). It also can greatly improve line tolerances for RF applications”

Are there specific R&D areas related to bare circuit board manufacturing that DOD could support to improve board performance?

- Yes, 24, 12%
- No, 29, 14%
- N/A, 149, 74%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

What advanced bare circuit board-related technologies should DOD support to better enable manufacturers to meet future national security requirements?

- Stretchable/wearable electronics: 24
- Advanced embedded active/passive device methods: 24
- Enhanced solid copper via fill methods: 22
- Other: 17
- Development of very thin unsupported dielectrics: 15
- Printed electronics (additive, 3-D, etc.): 12
- Direct IC die-on-board ultra high density interconnects: 8
- Sub-10 micrometer photoresists, etchants: 7
- Ultra smooth copper foil: 6

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

Maximum 3 responses per facility

53 respondents
Research & Development –
PCB Technology For DOD To Support: Industry Comments

Enhanced solid copper via fill methods
- “Electronics are getting denser and reliable processes need to be developed.”
- “Improved reliability vs. current via hole fill methodologies. Now a capacity constraint in plating. Additional development needed.”
- “U.S. manufacturing needs to be at the forefront of capability and technology.”

Advanced embedded active/passive device methods
- “Embedded active components to prevent loss of IP and/or counterfeiting.”
- “Embedded active/passive devices is a discriminator and could be moved forward more quickly with DOD support.”
- “DOD should develop a "Trusted Foundry" type approach for PCB manufacturing.”

Other
- “Anti-tamper packaging and anti-counterfeit measures”
- “DOD needs to get on board with lead-free product”
- “eSurface for fine lines and better line tolerances”
- “High Temp Rigid Flex for future munitions and high speed missile applications”
- “Environmentally friendly PCB processing”
- “Ruggedized products for field applications”
- “Alternative Metal Finishes”
- “Flexible Hybrid Electronics for human and asset performance monitors, especially for monitoring the well being of the warfighter”
Research & Development
PCB Technology For DOD To Support: Industry Comments

Ultra smooth copper foil
- “Enhanced signal integrity”
- “May play a direct role in maintaining signal integrity in RF/Microwave material theater”
- “Helps electronic device performance”

Sub-10 micrometer photoresists, etchants
- “Developing very exact etching and printing capabilities can increase design density and push miniaturization in the market”

Direct IC die-on-board ultra high density interconnects
- “For reduction in size, weight, and power (SWaP) for aerospace and defense applications”
- “U.S. manufacturing needs to be a the forefront of capability and technology”

Printed electronics (additive, 3-D, etc.)
- “Customer interest”
- “Potential for advancing the concept to multiple applications with 3-D, multi-layer technologies”

Stretchable/wearable electronics
- “Advance the use of printable material on polyimide”
- “Forming and/or embedding circuits as part for clothing, pack, helmet, etc….will lighten war fighter load while improving mission assurance(traceability/communications/etc.)”

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
U.S. Bare PCB Facility Capital Expenditures (2012-2015)

- **Total CAPEX Expenditures**
  - 2012: $112,399
  - 2013: $125,432
  - 2014: $106,814
  - 2015: $113,623

- **Bare Circuit Board-Related CAPEX**
  - 2012: $81,984
  - 2013: $85,086
  - 2014: $75,008
  - 2015: $74,204

**Source:** U.S. Department of Commerce, Bureau of Industry and Security

**202 respondents**
U.S. Bare PCB Facility Capital Expenditures (2012-2015)

- Total CAPEX Expenditures
- Machinery, Equipment, and Vehicles
- Land, Buildings, and Leasehold Improvements
- IT, Computers, Software
- Other (reported)
- Bare circuit board-related Expenditures

<table>
<thead>
<tr>
<th>Year</th>
<th>Total CAPEX</th>
<th>Machinery, Equipment, and Vehicles</th>
<th>Land, Buildings, and Leasehold Improvements</th>
<th>IT, Computers, Software</th>
<th>Other (reported)</th>
<th>Bare circuit board-related Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>$112,399</td>
<td>$81,984</td>
<td>$19,182</td>
<td>$1,500</td>
<td>$19,182</td>
<td>$5,084</td>
</tr>
<tr>
<td>2013</td>
<td>$125,432</td>
<td>$101,708</td>
<td>$15,068</td>
<td>$2,769</td>
<td>$15,068</td>
<td>$5,749</td>
</tr>
<tr>
<td>2014</td>
<td>$106,814</td>
<td>$87,228</td>
<td>$9,373</td>
<td>$1,916</td>
<td>$9,373</td>
<td>$7,952</td>
</tr>
<tr>
<td>2015</td>
<td>$113,623</td>
<td>$93,678</td>
<td>$9,539</td>
<td>$1,296</td>
<td>$9,539</td>
<td>$8,871</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
From 2012 to 2015, were your organization's bare circuit board-related capital expenditures adversely impacted by reductions in U.S. Government defense spending?

- Yes: 45
- No: 114
- N/A: 24
- No response: 19

Source: U.S. Department of Commerce, Bureau of Industry and Security
Effects of USG Spending Cutbacks on CAPEX: Industry Comments

Facilities impacted by reductions in U.S. Government defense spending:

- “Many capital expenditure programs were delayed or reduced in volume”
- “There was an 80% loss of military orders in this time period. No new equipment needed”
- “Defense spending cuts resulted in program push outs and delays in funding for development applications”
- “Less purchase orders equals less investment”
- “Limited volumes of Aerospace/Defense products resulted in poor ROI to purchase new equipment”
- “Loss of revenue constrained capital expenditures”
- “Company capital budget has decreased as our sales numbers have decreased”
- “Reduction in sales dictates a cautious spending plan relating to capital expenditures”
- “Due to a decrease in sales and new contracts, we could not invest in as much equipment as needed”

Facilities NOT impacted by reductions in U.S. Government defense spending:

- “Did not have any government business”
- “Government sales are not a large portion of our revenue”
- “More affected by the financial crisis”
- “PWB demand and workforce numbers stayed relatively constant over this timeframe”

Source: U.S. Department of Commerce, Bureau of Industry and Security

Q10B 202 respondents
CAPEX: Top Priorities for U.S. PCB Manufacturers

Top 5 bare PCB-related CAPEX priorities (2016-2020) - Ranked

- Equipment for new technologies
- Equipment for existing technologies
- IT/computers/software
- Expanded facility
- Other

Q10,C

Equipment Priorities for New Technologies
- Flex and Rigid Flex capability
- Lead-free hot air solder leveling (HASL)
- Expand capacity in high density interconnect (HDI) technology
- Ink-jet nomenclature application
- Printed electronics
- Laser direct imaging equipment
- Advanced processing technologies and advanced materials
- Light emitting diode (LED)
- Application of masks and inks
- Sequential lamination equipment
- Solder mask spray unit + etcher
- High temperature lamination for fusion bonding
- Advanced develop-etch-strip / design (DES) equipment
- Drilling equipment for finer features
- Plasma etch
- Laser drill
- Optical routing
- Reverse pulse plate plating technologies
- Automated optical inspection equipment
- Electroless nickel immersion gold (ENIG) plating process
- Advanced test equipment
- Pulse rectification: electro-copper

Equipment Priorities for Existing Technologies
- High density interconnect (HDI) capability
- Permanganate Desmear
- Direct imaging
- Via fill and planarization equipment
- Laser direct imaging
- CMM
- Photo plotting system
- Lamination presses
- Develop-etch-strip / design (DES)
- Vacuum lamination presses
- Plasma etching
- Automated hole alignment, camera assisted drill
- Ink jet sprayer for solder mask
- Laser drills
- Legend Ink Jet Printing
- Deburr equipment
- Etching equipment
- Routing equipment
- Copper electroplating equipment
- Coordinate measurement machine (CMM)
- Advanced plating rectifiers for copper-filled vias
- Additional measurement equipment
- Electroless nickel immersion gold (ENIG) plating process
- Electrical test equipment

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
CHAPTER 9: EMPLOYMENT

- U.S. BARE PCB EMPLOYMENT - CHALLENGES
- EMPLOYMENT FIGURES (2012-2015)
- HIRING AND RETENTION
- KEY ISSUES ANTICIPATED
- WORKFORCE RETIREMENT AND REPLACEMENT
- WORK EXPERIENCE LEVELS
Employment – Challenges (2015)

• Thirty-six percent of BIS survey respondents reported current difficulties hiring and retaining employees.

• Top two key future workforce-related issues anticipated (2016-2020).
  ➢ Finding experienced workers – 65% of respondents
  ➢ Finding qualified workers – 52% of respondents

• Aging workforce and upcoming retirement is also an industry challenge.
  ➢ 13% of technical staff (scientists, engineers, R&D staff) expected to retire by 2020.

• Comments from U.S. PCB manufacturers include:
  ➢ “To expand we need qualified workers that just are not available”
  ➢ “The biggest challenge is to find qualified candidates who would be a good match”
  ➢ “Experienced workforce is aging, fewer new entrants to manufacturing”
  ➢ “Harder to find circuit board related experience. We have to do 100% OTJ training”
  ➢ “Much of the work in our industry has moved offshore affecting both local and US talent availability. It can be difficult to attract new talent in what is considered to be a diminishing market.”
  ➢ “Many senior level employees leaving within the next 5 years.”
  ➢ “Average age of 58.”
  ➢ “Many workers over at or near retirement age.”
  ➢ “Lower demand over the years led to workforce reductions instead of hiring. As a result existing workforce is the more experienced and now facing retirement age”
  ➢ “Significant portion of our workforce will be retirement-eligible in 5-years”
  ➢ “Anticipating large number of retirements in next five years; aging workforce”

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Industry Hiring and Retention Issues (2015)

**Does this facility have difficulty hiring and/or retaining any types of employees?**

- **Yes**, 73, 36%
- **No**, 88, 44%
- **N/A**, 41, 20%

202 respondents

**U.S. Bare PCB Workforce: Key Issues Anticipated (2016-2020)**

- Finding experienced workers: 132
- Finding qualified workers: 106
- Attracting workers to location: 62
- Employee turnover: 57
- Significant portion of workforce retiring: 57
- Finding U.S. citizens: 35
- Finding workers able to get security clearances: 16

202 respondents

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
U.S. Bare PCB Workforce

Hiring/Retention Difficulty by Job Category (2015)

Does this facility have difficulty hiring and/or retaining any types of employees?

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017
Employment – Challenges (2015)

• The industry’s ability to recruit and hire a qualified sustainable workforce seems to be limited by two key factors.
  ➢ Shortage of prospective employees who have the essential skills needed to be successful in a PCB manufacturing capacity.
  ➢ A shortage of young people interested in manufacturing careers in general.

• These are exacerbated by the impression that U.S. PCB manufacturing is a diminishing industry.

• Many manufacturing companies are facing seemingly contradictory goals in order to remain competitive – a need both to cut workforce costs and at the same time to invest in the workforce so that it can do more.

• Industry Needs:
  ➢ Address the skill gaps in the industry’s labor market by working with academic institutions to develop and grow technical education workforce development programs such as internships, apprenticeships, tuition reimbursements, etc.
  ➢ Community colleges can have a critical role to play because they understand the needs of local employers, and can design programs and courses that are responsive to local employers’ needs.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
13% of technical staff (scientists, engineers, R&D staff) are expected to retire by 2020.
U.S. Bare PCB Workforce - Total v. Production Line

U.S. Bare PCB Facilities Workforce (2012-2015)

- Administrative, Management, & Legal Staff
- Engineers, Scientists, and R&D Staff
- Facility & Maintenance Staff
- FTE Employees
- Information Technology Professionals
- Marketing & Sales
- Production Line Workers
- Testing Operators, Quality Control, and Support Technicians
- Other

Q11a,A

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
U.S. Bare PCB Facility Workforce – Geographic Location (2015)

Top 10 States

<table>
<thead>
<tr>
<th>State</th>
<th>Number of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>5,349</td>
</tr>
<tr>
<td>WI</td>
<td>1,403</td>
</tr>
<tr>
<td>MN</td>
<td>1,215</td>
</tr>
<tr>
<td>IL</td>
<td>1,160</td>
</tr>
<tr>
<td>NY</td>
<td>920</td>
</tr>
<tr>
<td>OR</td>
<td>839</td>
</tr>
<tr>
<td>CO</td>
<td>665</td>
</tr>
<tr>
<td>VA</td>
<td>468</td>
</tr>
<tr>
<td>UT</td>
<td>438</td>
</tr>
<tr>
<td>NH</td>
<td>417</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
U.S. Bare PCB Workforce – Technical Staff Turnover

Workforce – Technical Staff Retirement/Replacement (2016-2020)

- What % of this facility’s technical staff do you expect to RETIRE within the next five years?
- What % of this facility’s technical staff do you expect to have to REPLACE over the next five years?

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
U.S. Bare PCB Workforce
Level of Work Experience for U.S./Non-U.S. Workers (2015)

Estimated number of employees by years of work experience

- **U.S. Citizens**
  - Five or Fewer Years: 3,709 (9%)
  - 6-10 Years: 2,830 (7%)
  - 11-20 Years: 3,574 (7%)
  - Over 20 Years: 3,325 (7%)

- **Non-U.S. Citizens**
  - Five or Fewer Years: 351 (9%)
  - 6-10 Years: 259 (8%)
  - 11-20 Years: 271 (7%)
  - Over 20 Years: 245 (7%)

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
202 respondents
U.S. Bare PCB Workforce
Level of Work Experience by Job Category (2015)

- Over 20 Years
- 11-20 Years
- 6-10 Years
- Five or Fewer Years

Other includes: Manufacturing Technician, Production Worker, Quality (AOI, QC, QE, QA, Cross Section), Management, Sales, Shipping, etc.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
CHAPTER 10: COMPETITIVE FACTORS

- PROJECTED CHANGES IN OPERATIONS
- ENVIRONMENTAL REGULATION IMPACT
- FACTORS EFFECTING INTEREST IN USG BUSINESS
- COST EFFECT OF DOD STANDARD MIL-PRFP331032
- RETURN-ON-INVESTMENT (ROI) SUFFICIENCY
- INDUSTRY CONSOLIDATION AND FOREIGN ACQUISITION EXPECTATIONS
- IMPACT OF POTENTIAL USG ACTIONS

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Competitive Factors
Primary Projected Changes for U.S. Bare PCB Facilities

Primary Expected Change in Operations (2016-2020)

- Modernization: 66
- None: 61
- Expansion: 43
- Potential Closure: 21
- Contraction: 6
- Other: 5

- At this rate we just manage to keep the doors open
- Change of ownership
- Closed down manufacturing operations in 2015
- Owner is planning to retire and successor ownership is uncertain
- RF growth

Source: U.S. Department of Commerce, Bureau of Industry and Security
202 respondents
Competitive Factors
Changes Expected at U.S. Bare PCB Facilities (2016-2020)

- Small <$10M
- Medium $10M-$40M
- Large >$40M

<table>
<thead>
<tr>
<th>Category</th>
<th>Small &lt;$10M</th>
<th>Medium $10M-$40M</th>
<th>Large &gt;$40M</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>66</td>
<td>55</td>
<td>61</td>
</tr>
<tr>
<td>Defense</td>
<td>43</td>
<td>34</td>
<td>39</td>
</tr>
<tr>
<td>Contraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expansion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modernization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential Closure</td>
<td>21</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

197 Respondents
Competitive Factors - Facilities Eyeing Contraction (2016-2020)

- 27 facilities reported expecting to contract or potentially close in the next five years
  - 13 reported some level of defense end use sales
  - 9 support USG programs
  - 8 are dependent on USG business
  - 5 reported net income <0 each year

Financial Risk Rating

- High/Severe Risk: 3 facilities
- Moderate/Elevated Risk: 11 facilities
- Low/Neutral Risk: 9 facilities
- Uncalculated: 4 facilities

Net Income < $0

- 2012: 13 facilities
- 2013: 13 facilities
- 2014: 13 facilities
- 2015: 13 facilities

U.S. Bare PCB Sales

- Government Sales
- Non-Government Sales

<table>
<thead>
<tr>
<th>Year</th>
<th>Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>$38</td>
</tr>
<tr>
<td>2013</td>
<td>$35</td>
</tr>
<tr>
<td>2014</td>
<td>$33</td>
</tr>
<tr>
<td>2015</td>
<td>$30</td>
</tr>
</tbody>
</table>

Manufacturing Capabilities – Board Types

- Rigid PCBs: 27 facilities
- Flex PCBs: 14 facilities
- Rigid-Flex PCBs: 6 facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q12a, A
Competitive Factors

Have recent changes in environmental control regulations adversely affected this facility’s capability to compete against circuit board manufacturers in other countries?

- No: 80, 40%
- N/A: 10, 5%
- Yes: 112, 55%

Industry Comments:

- “A great deal of our budget has to be spent to maintain and monitor all our waste treatment. We spend more than 20% of our budget to remove "hazardous" waste.”
- “Continued focus on reduction of copper levels and other metals have forced us to invest money in treatment equipment rather than equipment that would enhance our capability. In addition, continuous monitoring of effluents and reporting requirements result in increased labor expenses.”
- “For every $1 dollar we spend on our waters supply, it costs us more than $12 in waste treatment and regulation fees. I'm sure that producers in other countries have to spend less than 1/4 of our waste treatment and regulation costs.”
- “Mandatory Federal, State and Local Certifications, waste treatment, recycling and Permits are very costly per year and need to be covered in product pricing, which puts US Electronic manufacturers at a huge disadvantage. The regulations have been getting worse over the last 8 years.”
- “Our regulatory conditions continue to be more stringent and expensive to comply with while our overseas competitors have little or no environmental compliance or related expenses.”
- “Very difficult for small company to comply with documents required by these regulations.”
- “We are more regulated than some countries and the cost to comply with more and tighter regulations directly impacts price which can result in pricing us out of being competitive.”
- “We have no problem with compliance and are advocates of the environment but it puts us at a competitive disadvantage.”
- “Labor costs typically biggest challenge vs other countries.”
- “No significant changes past several years.”
- “No, we continue to invest in the EH&S sector of our business.”
- “Not "recent" but overall regulatory issues are a time issue.”
- “Not yet, but it will certainly be a concern soon.”
- “We do not have wet processes in house.”

Q12a,B1

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Competitive Factors
Forecast Closures of U.S. Bare PCB Tin-Lead Facilities (2015)

Will environmental regulations force this facility to cease manufacturing tin-lead circuit boards?

- No: 151 (75%)
- Not Applicable: 23 (11%)
- Yes: 28 (14%)

If yes, what year is this facility expected to cease producing tin-lead circuit boards?

- 2015: 4
- 2016: 2
- 2017: 2
- 2018: 1
- 2020: 5
- 2021: 2
- 2022: 1
- 2026: 1
- 2030: 1
- 2125: 1

*Note: Eight “Yes” respondents either did not provide a year or provided a year prior to the period covered in the survey.
Competitive Factors
Facilities Affected by Limits on Storage of Bare PCB Materials (2015)

Do environmental regulations cause this facility to keep smaller quantities of circuit board manufacturing materials in inventory than what you might otherwise consider optimal?

- **No**: 43, 21%
- **N/A**: 20, 10%
- **Yes**: 139, 69%

**Industry Comments:**

- “Chemical Storage is a problem.”
- “DHS (department of homeland security) has caused change to several input products and reduced the amounts of which may be maintained at the facility resulting in increased management, material and net product cost.”
- “Fire code limits our raw materials and SQG status does not allow for efficient use of hazardous waste transportation.”
- “If we keep more than the government thinks we should, then we have to pay more fees for being a large producer of product.”
- “Regulations coupled with limited storage space.”
- “Regulations only allow us to keep certain quantities of acids without moving into the next tier level.”
- “Storage requirements preclude large volumes of chemistries.”
- “Yes and No. Decreases in business volume has more of an impact on inventory levels. Inventory comes with carrying cost, so there is constant pressure to reduce inventory.”
- “Chemical suppliers willing to hold inventory for us.”
- “Circuit board materials and chemicals are ordered and replenished based on product demands driven by SAP.”
- “Environmental regulations are not covering the amount of manufacturing materials in inventory as of this point. Only waste materials.”
- “No issues with what we are allowed to keep. Reduced quantities occur because we cannot afford to keep money tied up in excess inactive inventory.”
- “No, orders are built to order. Industry changes too much to plan stock.”
- “This is true with chemicals, not material.”
- “We are a small shop and our footprint fits.”
- “We have sized our operations to meet the environmental regulations. Consignment and stocking programs are sufficient to meet our requirements.”

- DoD is often perceived as a difficult customer for small businesses or commercial businesses.
- Challenges:
  - Unique requirements - highly specialized boards, special functions and requirements.
  - Diminishing purchasing position in the overall PCB market.
  - Demand for higher technical performance at an affordable cost.
  - Administrative burden, low-volume, infrequent orders.
  - Legacy products production – costs and challenges.

Indicate whether the following factors affect this facility's interest in USG business.

- Insufficient Profit Margin: 47 may cause, 80 reduce interest
- Paperwork/Requirements: 24 may cause, 88 reduce interest
- Slow Payment: 23 may cause, 60 reduce interest
- Infrequent Orders: 19 may cause, 58 reduce interest
- One-off orders: 9 may cause, 21 reduce interest
- Small Production Lots: 8 may cause, 20 reduce interest
- Intellectual Property Protection: 6 may cause, 11 reduce interest

Other Factors:
- ITAR & FEDBID.com
- Employment Rates/Future Additions

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Competitive Factors

Indicate how DOD requirements to use MIL-PRF-31032 standards affect your costs relative to other existing standards?

Estimated Change Relative to MIL-P-50884C*

*DoD standard for the manufacture of flexible and rigid-flex printed circuit boards that was replaced by MIL-PRF-31032.

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

43 respondents
Competitive Factors

Indicate how DOD requirements to use MIL-PRF-31032 standards affect your costs relative to other existing standards?

Estimated Change Relative to IPC-6012 Class 3*

*Covers qualification and performance specifications of single- or multi-sided rigid printed boards

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q12a, D

61 respondents

- A commercially healthy and viable PCB industrial base is essential in order to support DoD needs and requirements.
- DoD domestic sourcing can help support a healthy, robust and technically advanced domestic supply base that can compete commercially.

To what extent is this facility’s continued ability to manufacture bare circuit boards for USG Customers dependent on the viability of your Commercial business?

- Significantly: 38, 19%
- Moderately: 74, 37%
- Somewhat: 31, 15%

66% Dependent

To what extent is this facility’s continued ability to manufacture bare circuit boards for Commercial Customers dependent on the viability of your USG business?

- Significantly: 33, 16%
- Moderately: 37, 18%
- Somewhat: 70, 35%
- Not at all: 24, 12%

49% Dependent

Source: U.S. Department of Commerce, Bureau of Industry and Security
Competitive Factors
Adequacy of Return-on-Investment for U.S. Bare PCB Facilities (2015)

Is the return-on-investment (ROI) associated with this facility's bare circuit board manufacturing business sufficient relative to capital requirements and business risk?

<table>
<thead>
<tr>
<th></th>
<th>Commercial Manufacturing</th>
<th>Defense-related Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>112</td>
<td>82</td>
</tr>
<tr>
<td>No</td>
<td>51</td>
<td>46</td>
</tr>
<tr>
<td>N/A</td>
<td>39</td>
<td>74</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Q12b, A

202 respondents
Competitive Factors
Projections for U.S. Bare PCB Facility Consolidation (2016-2020)

What level of overall industry consolidation do you expect to occur in the U.S. bare circuit board industry in the next five years?

Q12b, B

Number of Facilities

None | Minimal | Moderate | Major
--- | --- | --- | ---
13 | 61 | 91 | 37

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Competitive Factors

Key Factors Driving Consolidation

- Increased foreign competition: 107
- Larger companies possess market advantages: 63
- Cost reduction: 41
- Other: 33
- Diminishing Commercial orders: 26
- Not technologically competitive: 23
- Excess production capacity: 16
- Shrinking USG orders: 11
- Improved production efficiency: 8

Number of Facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Competitive Factors
Consolidation Drivers Identified by U.S. PCB Companies (2015)

Percent of Companies Identifying Key Factor as Cause for Consolidation

- Increased foreign competition: 33%
- Larger companies possess market advantages: 19%
- Cost reduction: 13%
- Other: 10%
- Diminishing Commercial orders: 8%
- Not technologically competitive: 7%
- Excess production capacity: 5%
- Shrinking USG orders: 3%
- Improved production efficiency: 2%
- Improved production efficiency: 2%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Competitive Factors
Key Drivers for Consolidation: Industry Comments

- “Foreign competition and low profitability both result in some competitors discontinuing operations. Seems like some leave the industry every year.”
- “Consolidation to reduce overhead compared to the sales price pressure.”
- “High capital equipment cost; and required annual software license purchase.”
- “Some larger companies are buying the customer lists of smaller companies in order to capture a larger percentage of the market share.”
- “More small manufacturers will continue closing facility because they do not have significant assets and business.”
- “The remaining small to midsize PCB fabricators in the US which have excellent process controls will be consolidated into larger companies to eliminate competition.”
- “Large portion of the US bare circuit board industry are sub $10 million in revenue that have not been able to recapitalize and have aging ownership.”
- “US companies that cannot make profit under a given market condition will eventually go out of business. There will always going to be increase foreign competition, large companies gobbling up smaller ones, and a majority of smaller companies not being able to reinvest in business to keep up with customer’s needs.”
- “Large companies do not like dealing with small suppliers.”
- “Between foreign competition and larger companies taking over the market share and opening branches on foreign soil it is hard to see the viability of the small PCB owner in the US without assistance in import limitations and environmental regulations.”
- “The Asian market has driven the commercial market share out of the country. The small companies cannot afford the equipment needed for technology advancement.”
- “Capital equipment costs, labor costs and locations.”
- “The Printed Circuit Board is in the decline phase of its life cycle. Industry value added (IVA), which measures an industry’s contribution to the U.S. economy, is projected to decline at an annualized 3.1% …to 2021. By contrast, U.S. GDP is forecast to grow at an annualized 2.3% during the same 10-year period. Industries with lower IVA growth rates compared with GDP indicate a declining status.”
Competitive Factors
Key Drivers for Consolidation: Industry Comments

- “The main issue with the US PCB industry is the Chinese PCB industry. Basically the only work left in the US are USG jobs that must be made here and commercial jobs where the design owners do not want the boards made China. The cost advantage that the Chinese companies have is just too luring for most companies to ignore trying and then continuing to use the Chinese companies. Even poor quality, slow delivery, language barriers, etc. can all be ignored to a certain extent if the cost reduction is that good, and in most cases it is.”
- “Lack of capital investments by these facilities makes them non-competitive technologically – and therefore do not have the capability to meet today’s demands.”
- “Other manufacturers globally have lower cost bases, but also increasing in their technical capabilities quickly.”
- “Many small shops not technologically capable of smaller lines and spaces.”
- “Large government supported growth within China.”
- “Major consolidation has already occurred. Further consolidation is likely to continue. USG is in serious risk on being held hostage by 1 or 2 major suppliers and losing what is left of the bare board circuit board industry. This could severely impact DOD’s ability to respond quickly in a real international conflict or crisis.”
- “Commercial customers want cheaper prices and go to China. The USG doesn't seem to have that much work for U.S. Electronics manufacturers.”
- “Many consolidations have already occurred in recent years and there are a limited amount of manufacturers remaining in the U.S.”
- “Currently China dominates PCB manufacturing, but I look for other Asian counties to play a larger role in near future. In the U.S., only the remaining large public and private PCB companies will be able to afford the necessary capital costs for acquiring state-of-the-art equipment.”
- “Too costly to operate locally. Diminishing technical resources.”
- “First, the cost of capital; and Second, key labor/technical resource retirements.”
Competitive Factors
Outlook for Foreign Acquisitions of U.S. Bare PCB Facilities (2016-2020)

What level of foreign acquisition of U.S. bare circuit board manufacturers do you expect in the next five years?

- Minimal: 100
- None: 45
- Moderate: 36
- Major: 21

202 respondents

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Which of the following impacts do you anticipate from consolidation in the number of U.S. bare circuit board manufacturing facilities?

- Shrinkage in Manufacturing Workforce
  - Yes: 166
  - No: 28
  - N/A: 10

- Small Companies Less Able to Compete
  - Yes: 166
  - No: 33
  - N/A: 8

- Pricing Advantage for Large Board Manufacturers
  - Yes: 162
  - No: 35
  - N/A: 3

- Greater Dependence on Non-U.S. Materials
  - Yes: 148
  - No: 44
  - N/A: 5

- Fewer U.S. Materials Manufacturers
  - Yes: 145
  - No: 49
  - N/A: 3

- Increased Market Share for Non-U.S. Companies
  - Yes: 143
  - No: 51
  - N/A: 6

- Higher Material Costs
  - Yes: 139
  - No: 60
  - N/A: 8

- Reduced Domestic Board Capability
  - Yes: 136
  - No: 60
  - N/A: 8

- Higher Prices for Bare Board Companies
  - Yes: 106
  - No: 87
  - N/A: 9

*Other expected impacts listed were – Cycle Time, Reduction in Capabilities Available, Stringent regulations in the circuit board industry requires smaller companies to eliminate certain processes and contract them out which raises our prices, good for customers in region of PCB manufacturing.
Small Facilities

Which of the following impacts do you anticipate from consolidation in the number of U.S. bare circuit board manufacturing facilities?

- Small companies less able to compete
- Pricing advantage for larger board manufacturers
- Shrinkage in manufacturing workforce
- Fewer U.S. materials manufacturers
- Increased market share for non-U.S. companies
- Higher material costs
- Reduced domestic board capability
- Greater dependence on non-U.S. materials
- Higher prices for bare board customers

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

146 respondents

Medium Facilities

Which of the following impacts do you anticipate from consolidation in the number of U.S. bare circuit board manufacturing facilities?

- Shrinkage in manufacturing workforce
- Greater dependence on non-U.S. materials
- Small companies less able to compete
- Pricing advantage for larger board manufacturers
- Fewer U.S. materials manufacturers
- Increased market share for non-U.S. companies
- Reduced domestic board capability
- Higher material costs
- Higher prices for bare board customers

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

46 respondents
Large Facilities

Which of the following impacts do you anticipate from consolidation in the number of U.S. bare circuit board manufacturing facilities?

- Shrinkage in manufacturing workforce: 9 facilities
- Greater dependence on non-U.S. materials: 9 facilities
- Higher prices for bare board customers: 8 facilities
- Small companies less able to compete: 3 facilities
- Pricing advantage for larger board manufacturers: 3 facilities
- Fewer U.S. materials manufacturers: 3 facilities
- Increased market share for non-U.S. companies: 2 facilities
- Reduced domestic board capability: 2 facilities
- Higher material costs: 2 facilities

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

10 respondents
### Competitive Factors

**Respondent Views of Potential USG Bare PCB Actions (2015)**

What impact would each of the following potential USG actions have on your business?

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Benefit</th>
<th>Harm</th>
<th>No Change</th>
<th>Unclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement for Defense Systems Product Manufacturers Registered on QML/QPL</td>
<td>115</td>
<td>14</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>Requirement for defense systems boards manufactured in the U.S. by &quot;trusted&quot; suppliers</td>
<td>148</td>
<td>6</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>Critical Systems Boards Produced in the U.S.</td>
<td>117</td>
<td>13</td>
<td>27</td>
<td>45</td>
</tr>
<tr>
<td>DOD adds circuit board laminate and related materials to the Defense National Stockpile</td>
<td>72</td>
<td>6</td>
<td>55</td>
<td>67</td>
</tr>
<tr>
<td>Requirement that Electronic Systems use U.S. manufactured boards</td>
<td>168</td>
<td>2</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Increased Funding of targeted PCB Manufacturing tech R&amp;D</td>
<td>117</td>
<td>1</td>
<td>44</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security

202 respondents
Competitive Factors – General Industry Comments

• “Cost of compliance to Mil specs, etc. could result in a few suppliers getting all the business. Our business serves medical market, industrial market and military markets. Separate and unique certifications and systems compliance for each segment results in a lot of additional (LOW VALUE) effort and support.”

• “Make it easier for small manufacturers, not harder.”

• “Needed for national defense concerns and keeping high quality product.”

• “PWB companies need help in the U.S. The foreign PWB companies have taken the lion’s share of our work and product. The future looks uncertain.”

• “Smaller shops can help an keep costs down if they are given help and opportunity to be a part of the supply chain to DOD.”

• “State and Federal laws should be passed that all circuit boards for city, county, government to be paid with tax papers money should be built in the USA by the tax payers. Small list other then defense, Lighting, signs, cameras, police apparel, equipment, etc.”

• “The components to go on the circuit is made offshore. The copper clad to make a circuit board is been made offshore for years. In 5 years we will no longer be able to produce a circuit board when we can’t buy any copper clad material ……………”

• “They should visit PCB facilities make sure the boards are actually produced in the USA. Also, ISO, ASA certification does not dictate good bare boards! Sometimes specialty [companies] can manufacture repeatable and accountable boards without certification!”

• “USG should put tariff on overseas boards.”
CHAPTER 11: CYBER SECURITY

• INTERNAL AND EXTERNAL IT NETWORKS MANAGEMENT
• PROTECTION OF COMMERCIALLY SENSITIVE INFORMATION (CSI)
• IMPACT OF CYBER EVENTS RELATED TO MALICIOUS ACTIVITY
Cyber Security

PCB Facilities With IT Networks Exposed to Internet (2015)

Does your organization's internal network connect to the Internet?

- Yes, 167, 83%
- No, 34, 17%

Q13a,A

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Cyber Security
Management of Internal Networks (2015)

Indicate who is responsible for your organization's internal IT networks:

- Internal IT Dept. & U.S. external provider(s): 134
- Internal IT Dept. & Only U.S. external provider(s): 24
- Only U.S. external provider(s): 23
- Not Applicable: 20
- Only non-U.S. external provider(s): 1
- Internal IT Dept. & U.S. & non-U.S. external provider(s): 0
- U.S. and non-U.S. external provider(s): 0

Source: U.S. Department of Commerce, Bureau of Industry and Security
Cyber Security
Management of External Networks (2015)

Indicate who is responsible for your organization's external IT networks:

- Internal IT Dept.: 71
- Not Applicable: 57
- Internal IT Dept. & U.S. & non-U.S. external provider(s): 38
- Internal IT Dept. & U.S. external provider(s): 31
- Only non-U.S. external provider(s): 3
- Only U.S. external provider(s): 1
- U.S. and non-U.S. external provider(s): 1

Source: U.S. Department of Commerce, Bureau of Industry and Security
Cyber Security
Protection of Commercially Sensitive Information (CSI) (2015)

Does this facility have defined, structured methods for actively protecting the following types of Commercially Sensitive Information?

- Patent and trademark information
- Research & Development related information
- Internal communications including negotiation points, merger and…
- Supply chain and sourcing information
- Manufacturing and production line information
- Information subject to export control regulations (EAR and/or ITAR)
- Regulatory/compliance information
- Intellectual property related information
- Human Resources/Employee data
- Financial Information and records
- Customer/client information

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Cyber Security
Impact of Incidents on IT Security Budget (2015)

Have recent cyber incidents across the marketplace caused your organization to increase its information security budget?

- No 102, 51%
- N/A 27, 13%
- Yes 73, 36%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Cyber Security
Storage of Commercially Sensitive Information (CSI) (2015)

Estimate the percentage of your organization's commercially sensitive information (CSI) that is stored with:

- External Cloud Service Providers
- External Data Storage Providers

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Cyber Security
Storage of Commercially Sensitive Information (CSI) (2015)

Does your organization restrict or prohibit your external cloud service or external data storage provider(s) from storing Commercially Sensitive Information outside of the U.S.?

- Yes, 83, 41%
- No, 17, 8%
- N/A
- Unknown, 5, 3%

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Indicate the level of impact each of the following types of events attributed to malicious cyber activity has had on this facility since 2012.

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Major</th>
<th>Moderate</th>
<th>Minimal</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>User idle time &amp; lost productivity b/c of downtime or systems performance delays</td>
<td>11</td>
<td>65</td>
<td>7</td>
<td>119</td>
</tr>
<tr>
<td>Disruption to normal operations b/c of system availability problems</td>
<td>11</td>
<td>4</td>
<td>51</td>
<td>136</td>
</tr>
<tr>
<td>Business interruption</td>
<td>8</td>
<td>4</td>
<td>50</td>
<td>140</td>
</tr>
<tr>
<td>Incurred cost of damage assessment &amp; remediation</td>
<td>5</td>
<td>8</td>
<td>26</td>
<td>163</td>
</tr>
<tr>
<td>Damage to company production capabilities or systems</td>
<td>7</td>
<td>19</td>
<td>174</td>
<td>174</td>
</tr>
<tr>
<td>Damage or theft of IT assets &amp; infrastructure</td>
<td>9</td>
<td>18</td>
<td>174</td>
<td>174</td>
</tr>
<tr>
<td>Damage to software and/or source code</td>
<td>7</td>
<td>17</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>Destruction of information asset</td>
<td>6</td>
<td>12</td>
<td>181</td>
<td>181</td>
</tr>
<tr>
<td>Reputation loss, market share, &amp; brand damages</td>
<td>11</td>
<td></td>
<td>186</td>
<td>186</td>
</tr>
<tr>
<td>Theft of personnel information</td>
<td>13</td>
<td></td>
<td>186</td>
<td>186</td>
</tr>
<tr>
<td>Exfiltration of CSI data</td>
<td>8</td>
<td></td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td>Theft of software and/or source code</td>
<td>7</td>
<td></td>
<td>192</td>
<td>192</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Cyber Security – Idle Time Tied to Malicious Activity

Levels of impact of idle time and lost productivity at U.S. Bare PCB manufacturing facilities attributed to malicious cyber activity (2012-2015)

All Bare PCB Facilities

- Major - 11
- Moderate - 7
- Minimal - 65
- None - 119

202 Respondents

Bare PCB Facilities with Defense End Use Applications

- Major - 8
- Moderate - 6
- Minimal - 45
- None - 86

145 Respondents

Q13a

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Cyber Security - General Industry Comments

• “Cyber attacks or hacking are always a concern for the IT department. Computer and software upgrades are always being considered.”

• “External Data Storage is done for archives/backups of critical data.”

• “Design, manufacturing and product documentation data, assets are all stored on local servers.”

• “No cyber damage.”

• “No incidents related to cyber security to date.”

• “We are aware of DFARs requirements associated with cybersecurity. Our IT management monitors and would report any event as applicable.”

• “We do not use cloud services or any other off site storage of data.”

• “We outsource IT and data storage back up with a local U.S. service provider.”

• “We take steps to limit our exposure cyber threats.”
CHAPTER 12: CHALLENGES AND OUTREACH

• INDUSTRY CHALLENGES
• AREAS OF OUTREACH INTEREST
### Current and Future Issues of Concern to Industry

<table>
<thead>
<tr>
<th>Issue</th>
<th>Current Impact</th>
<th>Future Impact</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aging equipment, facilities, or infrastructure</td>
<td>42</td>
<td>57</td>
<td>72</td>
</tr>
<tr>
<td>Healthcare costs</td>
<td>48</td>
<td>11</td>
<td>110</td>
</tr>
<tr>
<td>Competition - foreign</td>
<td>57</td>
<td>16</td>
<td>93</td>
</tr>
<tr>
<td>Labor availability/costs</td>
<td>28</td>
<td>35</td>
<td>99</td>
</tr>
<tr>
<td>Aging workforce</td>
<td>29</td>
<td>62</td>
<td>53</td>
</tr>
<tr>
<td>Competition - domestic</td>
<td>52</td>
<td>4</td>
<td>87</td>
</tr>
<tr>
<td>Worker/skills retention</td>
<td>20</td>
<td>21</td>
<td>99</td>
</tr>
<tr>
<td>Reduction in commercial demand</td>
<td>28</td>
<td>22</td>
<td>89</td>
</tr>
<tr>
<td>Taxes</td>
<td>22</td>
<td>5</td>
<td>111</td>
</tr>
<tr>
<td>Environmental regulations/remediation - domestic</td>
<td>36</td>
<td>22</td>
<td>79</td>
</tr>
<tr>
<td>Government regulatory burden</td>
<td>25</td>
<td>10</td>
<td>76</td>
</tr>
<tr>
<td>Reduction in USG demand</td>
<td>15</td>
<td>17</td>
<td>72</td>
</tr>
<tr>
<td>Health and safety regulations</td>
<td>21</td>
<td>11</td>
<td>72</td>
</tr>
<tr>
<td>Qualifications/certifications</td>
<td>16</td>
<td>19</td>
<td>64</td>
</tr>
<tr>
<td>Cyber security</td>
<td>22</td>
<td>31</td>
<td>39</td>
</tr>
<tr>
<td>Material input availability</td>
<td>5</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Obsolescence</td>
<td>16</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td>Government purchasing volatility</td>
<td>22</td>
<td>11</td>
<td>38</td>
</tr>
<tr>
<td>Environmental regulations/remediation - foreign</td>
<td>13</td>
<td>19</td>
<td>35</td>
</tr>
<tr>
<td>Proximity to suppliers</td>
<td>7</td>
<td>22</td>
<td>33</td>
</tr>
</tbody>
</table>

*Source: U.S. Department of Commerce, Bureau of Industry and Security*

*202 respondents*
Challenges – Issues Affecting Bare PCB Producers

- Healthcare costs
- Competition - domestic
- Competition - foreign
- Taxes
- Government regulatory burden
- Reduction in USG demand
- Reduction in commercial demand
- Labor availability/costs
- Aging workforce
- Aging equipment, facilities, or infrastructure
- Environmental regulations/remediation - domestic
- Worker/skills retention
- Government purchasing volatility
- Cyber security
- R&D costs
- Intellectual property/patent infringement
- Health and safety regulations
- Qualifications/certifications
- Proximity to suppliers
- Export controls/ITAR & EAR
- Environmental regulations/remediation - foreign
- Material input availability
- Government acquisition process
- Obsolescence
- Quality of material inputs
- Counterfeit parts
- Proximity to customers
- Pension costs
- Sustainable pricing for PCBs
- Imaging

Q14, A
202 respondents

Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017
Challenges – Top 5 Ranked Bare PCB Industry Key Issues

- Competition - foreign
- Aging equipment, facilities, or infrastructure
- Aging workforce
- Healthcare costs
- Competition - domestic
- Reduction in commercial demand
- Labor availability/costs
- Environmental regulations/remediation - domestic
- Worker/skills retention
- Reduction in USG demand
- Qualifications/certifications
- Government purchasing volatility
- Taxes
- R&D costs
- Quality of material inputs
- Health and safety regulations
- Cyber security
- Proximity to suppliers
- Proximity to customers
- Obsolescence
- Material input availability
- Intellectual property/patent infringement
- Government regulatory burden
- Government acquisition process
- Export controls/ITAR & EAR
- Environmental regulations/remediation - foreign

Q14, A

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
**Top 10 Areas of Outreach Interest**

1. Market Expansion/Business Growth - 89
2. Government Procurement Guidelines - 64
3. Continuous Improvement/Lean Manufacturing - 63
4. Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts - 59
5. Prototyping - 56
6. Technology Acceleration - 54
7. Quality Management and Control - 51
8. Cyber Security - 50
9. Design for Manufacturability - 49
10. Energy and Environmentally Conscious Manufacturing - 45

**Source:** U.S. Department of Commerce, Bureau of Industry and Security

**Q14,B**

202 respondents

U.S. Bare Printed Circuit Board Industry Assessment – 2017
Challenges - Interest in U.S. Government Outreach

Areas of Outreach Interest

- Market Expansion/Business Growth: 89
- Government Procurement Guidelines: 64
- Continuous Improvement/Lean Manufacturing: 63
- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts: 59
- Prototyping: 56
- Technology Acceleration: 54
- Quality Management and Control: 51
- Cyber Security: 50
- Design for Manufacturability: 49
- Energy and Environmentally Conscious Manufacturing: 45
- Export Licensing (ITAR/EAR): 44
- Supply Chain Optimization: 28
- Vendor/Material Sourcing: 24
- Export Assistance: 22
- Design for Assembly: 19
- Product Design: 17

Q14, B

Source: U.S. Department of Commerce, Bureau of Industry and Security

U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents
Challenges
Interest in U.S. Government Outreach: Industry Comments

• “Without SALES, no one can help us ….”
• “How can we get more work from DOD?”
• “Not interested in doing any government work”
• “[My company] is very interested in partnering with USG”
• “The biggest issue for our business continues to be a competitive issue with Asia. The cost of production is not the same for lots of reasons…”
• “We could use help from State or Federal government grants”
• “We have enough assistance available at present”
• “We have attended multiple EAR / ITAR seminars sponsored by the USG, but the information has been high level - often just to pointing us to confusing regulations…”
DEFENSE INDUSTRIAL BASE ASSESSMENT:
Bare Printed Circuit Board Manufacturers

SCOPE OF ASSESSMENT
The U.S. Department of Commerce, Bureau of Industry and Security (BIS), Office of Technology Evaluation, in coordination with the United States Navy, Naval Surface Warfare Center, Crane Division (NSWC Crane) is conducting an assessment of the U.S. industrial base for manufacturing bare printed circuit board products. The primary goal of this study is to assist the U.S. defense community in understanding the health and competitiveness of organizations manufacturing bare printed circuit boards for commercial and U.S. Government applications at facilities located in the United States.

The Secretary of the Navy is the Department of Defense (DOD) Defense Executive Agent for printed circuit board technology. NSWC Crane is the DOD Executive Agent technical lead for printed circuit board and interconnect technology. NSWC Crane provides acquisition engineering, in-service engineering, and technical support for sensors, electronics, electronic warfare, and special warfare weapons.

RESPONSE TO THIS SURVEY IS REQUIRED BY LAW
A response to this survey is required by law (50 U.S.C. App. Sec. 4555). Failure to respond can result in a maximum fine of $10,000, imprisonment of up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C App. Sec. 4555). Section 705 prohibits the publication or disclosure of this information unless the President determines that its withholding is contrary to the national defense. Information will not be shared with any non-government entity, other than in aggregate form. The information will be protected pursuant to the appropriate exemptions from disclosure under the Freedom of Information Act (FOIA), should it be the subject of a FOIA request.

Notwithstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB Control Number.

BURDEN ESTIMATE AND REQUEST FOR COMMENT
Public reporting burden for this collection of information is estimated to average 13 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information to BIS Information Collection Officer, Room 6883, Bureau of Industry and Security, U.S. Department of Commerce, Washington, D.C. 20230, and to the Office of Management and Budget, Paperwork Reduction Project (OMB Control No. 0694-0119), Washington, D.C. 20503.

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
# TABLE OF CONTENTS

| I  | General Instructions                  |
| II | Definitions                           |
| III| Respondent Profile                    |
| 1  | Organization Information              |
| 2  | Mergers, Acquisitions, Divestitures, and Joint Ventures |
| 3  | Customers and Competitors             |
| 4  | Interactions with the USG             |
| 5  | Manufacturing Capabilities            |
| 6  | Materials and Equipment               |
| 7  | Sales                                 |
| 8  | Financial Information                 |
| 9  | Research & Development                |
| 10 | Capital Expenditures                  |
| 11 | Workforce                             |
| 12 | Competitive Factors                   |
| 13 | Cyber Security                        |
| 14 | Challenges and Outreach Interest      |
| 15 | Certification                         |

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
## Section I: General Instructions

A. Your facility is required to complete this bare printed circuit board survey using an Excel template, which can be downloaded from the BIS website: [http://bis.doc.gov/printedcircuitboards](http://bis.doc.gov/printedcircuitboards). If you are not able to download the survey document, at your request BIS staff will e-mail the Excel survey template directly to you.

For your convenience, a PDF version of the survey containing required drop-down content is available on the BIS website to aid internal data collection. DO NOT SUBMIT the PDF version of the survey as your response to BIS. Should this occur, your facility will be required to resubmit the survey in the requested Excel format.

B. Respond to every question. Surveys that are not fully completed will be returned for completion. Use the comment boxes to provide any information to supplement responses provided in the survey form. Make sure to record a complete answer in the cell provided, even if the cell does not appear to expand to fit all the information.

**DO NOT CUT AND PASTE RESPONSES WITHIN THIS SURVEY.** Survey inputs should be completed by typing in responses or through use of a drop-down menu. The use of cut and paste can corrupt the survey template. If your survey response is corrupted as a result of cut and paste responses, a new survey will be sent to your organization for immediate completion.

C. **Do not disclose any Classified Information in this survey form.**

D. Estimates may be furnished in select instances but in sections that do not explicitly allow estimates you must contact BIS survey support staff before including estimates.

E. Upon completion of the survey, final review, and certification on the final page, transmit the survey via e-mail to: [printedcircuitboards@bis.doc.gov](mailto:printedcircuitboards@bis.doc.gov).

To arrange for the completed survey to be delivered on CD-ROM or DVD disc by private carrier, contact BIS survey staff.

Questions related to this Excel survey should be directed to: [printedcircuitboards@bis.doc.gov](mailto:printedcircuitboards@bis.doc.gov).

F. E-mail is the preferred method of contact.

You may also speak with a member of the BIS survey support staff by calling 202-482-6339.

For questions related to the overall scope of this Defense Industrial Base assessment, contact:

Brad Botwin, Director, Industrial Studies
Office of Technology Evaluation, Room 1093
U.S. Department of Commerce
1401 Constitution Avenue, NW
Washington, DC 20230

DO NOT submit completed surveys to Mr. Botwin's postal or e-mail address; all surveys must be submitted electronically to [printedcircuitboards@bis.doc.gov](mailto:printedcircuitboards@bis.doc.gov).

---

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Research</td>
<td>Systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. This activity includes work leading to the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes.</td>
</tr>
<tr>
<td>Authorizing Official</td>
<td>Executive officer or other representative of the corporation, division, business unit and/or facility who has the authority to execute this survey on behalf of the designated facility.</td>
</tr>
<tr>
<td>Bare Printed Circuit Board</td>
<td>A completed, tested circuit board ready to be populated with components to create a working system.</td>
</tr>
<tr>
<td>Basic Research</td>
<td>Systematic, scientific study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts.</td>
</tr>
<tr>
<td>Board Thickness</td>
<td>The overall thickness of the base material, all conductive material deposited thereon, and solder mask.</td>
</tr>
<tr>
<td>Commercial and Government Entity (CAGE)</td>
<td>Commercial and Government Entity (CAGE) Code identifies companies doing or wishing to do business with the U.S. Federal Government. The code is used to support mechanized government systems and provides a standardized method of identifying a given facility at a specific location. Find CAGE codes at <a href="https://cage.dla.mil/search/begin_search.aspx">https://cage.dla.mil/search/begin_search.aspx</a>.</td>
</tr>
<tr>
<td>Commercially Sensitive Information (CSI)</td>
<td>Privileged or proprietary information which, if compromised through alteration, corruption, loss, misuse, or unauthorized disclosure, could cause serious harm to the organization owning it.</td>
</tr>
<tr>
<td>Export Controls</td>
<td>1) Regulations administered by the Bureau of Industry and Security (BIS), U.S. Department of Commerce governing the export of dual-use technologies; 2) International Traffic in Arms Regulations (ITAR) administered by the U.S. Department of State governing products and services provided specifically for defense applications.</td>
</tr>
<tr>
<td>External Cloud Service Provider</td>
<td>A service model in which a company employs an external third-party service provider to maintain, manage, and back up business data at a remote location away from the company’s operating facilities. The use of shared third-party storage infrastructure by businesses can reduce capital, operations, storage, and security requirements, significantly lowering costs. Data is transmitted between the company and the cloud service provider via networks as needed.</td>
</tr>
<tr>
<td>External Data Storage Provider</td>
<td>A business that provides external data storage services to your company for data that is not currently held in your company's main data network work systems.</td>
</tr>
<tr>
<td>Flex</td>
<td>A flexible circuit board with printed circuitry on flexible base material consisting of one or more layers.</td>
</tr>
<tr>
<td>Full Time Equivalent (FTE) Employees</td>
<td>Employees who work for 40 hours in a normal work week. Convert part-time employees into “full time equivalents” by taking their work hours as a fraction of 40 hours.</td>
</tr>
<tr>
<td>Microvia</td>
<td>A conductive hole with a diameter of 0.005” or less that connects layers of a multi-layer printed circuit board. Microvias are used in blind and buried vias, but not for through-the-board connections. The term is often used to refer to any small geometry connection holes created by laser drilling.</td>
</tr>
<tr>
<td>North American Industry Classification System (NAICS) Code</td>
<td>North American Industry Classification System (NAICS) codes identify the category of product(s) or service(s) provided by an organization. Find NAICS codes at <a href="http://www.census.gov/epcd/www/naics.html">http://www.census.gov/epcd/www/naics.html</a>.</td>
</tr>
<tr>
<td>Planarization</td>
<td>Planarization is a mechanical sanding/polishing process to create a flat or planar surface across copper conductor on circuit boards.</td>
</tr>
<tr>
<td>Pre-Preg</td>
<td>A sheet of base dielectric laminate incorporating reinforcing material (typically glass fabric/mat, or aramid fabric/mat) impregnated with a resin cured to an intermediate stage (i.e. B-stage resin) where it is not fully cured.</td>
</tr>
<tr>
<td>Product/Process Development</td>
<td>Conceptualization and development of a product prior to the production of the product for customers.</td>
</tr>
<tr>
<td>Qualified manufacturers’ List (OML)</td>
<td>A list of manufacturers who have had their products examined and tested and who have satisfied all applicable U.S. Department of Defense qualification requirements for that product.</td>
</tr>
<tr>
<td>Qualified Products List (QPL)</td>
<td>A list of products, or family of products, that have met the qualification requirements set forth in the applicable specification, including appropriate product identification, tests or qualification reference, and the name and plant address of the manufacturer and authorized distributor.</td>
</tr>
<tr>
<td>Rigid</td>
<td>A rigid circuit board composed of resin and reinforcing material such as fiberglass that contains an electric conductor in a defined path to connect with devices and terminal connectors.</td>
</tr>
<tr>
<td>Rigid-Flex</td>
<td>One or more rigid circuit boards connected by a flexible circuit board.</td>
</tr>
<tr>
<td>Service</td>
<td>An intangible product (contrasted to a good, which is a tangible product). Services typically cannot be stored or transported, are instantly perishable, and come into existence at the time they are bought and consumed.</td>
</tr>
<tr>
<td>Single Source</td>
<td>An organization that is designated as the only accepted source for the supply of parts, components, materials, or services, even though other sources with equivalent technical know-how and production capability may exist.</td>
</tr>
<tr>
<td>Sole Source</td>
<td>An organization that is the only source for the supply of parts, components, materials, or services. No alternative U.S. or non-U.S. based suppliers exist other than the current supplier.</td>
</tr>
<tr>
<td>Supplier</td>
<td>An entity from which your facility obtains inputs. A supplier may be another firm with which you have a contractual relationship, or it may be another facility owned by the same parent organization. The inputs may be goods or services.</td>
</tr>
<tr>
<td>United States</td>
<td>The “United States” or “U.S.” includes the 50 states, Puerto Rico, the District of Columbia, the island of Guam, the Trust Territories, and the U.S. Virgin Islands.</td>
</tr>
<tr>
<td>Via</td>
<td>A plated feed-through hole that is used to route a trace vertically in the board from one layer to another. Vias are not used as connecting devices for component leads or for anchoring reinforcing material.</td>
</tr>
<tr>
<td>Via Structure</td>
<td>A description of vias (including microvias) incorporated in a multilayer circuit board product.</td>
</tr>
</tbody>
</table>
### Section III: Respondent Profile

**A.** Select the description that best identifies your organization:

<table>
<thead>
<tr>
<th>Description</th>
<th>Design Capability</th>
<th>Manufacture Capability</th>
<th>Assembly Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organization has a single facility, which is located in the U.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Organization has multiple facilities, but only one bare circuit board manufacturing facility in the U.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Organization has multiple facilities in the U.S. with bare circuit board manufacturing capabilities.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If your organization does not manufacture bare printed circuit boards in the U.S., contact BIS survey staff at printedcircuitboards@bis.doc.gov.

**B.** What capabilities does this facility have related to the production of bare printed circuit boards?

<table>
<thead>
<tr>
<th>Capability</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
### Section 1a: Organization Information

Provide the following information for this facility.

<table>
<thead>
<tr>
<th>Facility/Organization Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Street Address</td>
<td></td>
</tr>
<tr>
<td>City</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
</tr>
<tr>
<td>Zip Code</td>
<td></td>
</tr>
<tr>
<td>Website</td>
<td></td>
</tr>
<tr>
<td>Phone Number</td>
<td></td>
</tr>
<tr>
<td>Primary CAGE Code</td>
<td></td>
</tr>
</tbody>
</table>

Provide the following information for your parent organization(s), if applicable. If not applicable, insert "NA" in the Parent Name box.

<table>
<thead>
<tr>
<th>Parent Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Street Address</td>
<td></td>
</tr>
<tr>
<td>City</td>
<td></td>
</tr>
<tr>
<td>State/Province</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td></td>
</tr>
<tr>
<td>Postal Code/Zip Code</td>
<td></td>
</tr>
<tr>
<td>Parent Primary CAGE Code</td>
<td></td>
</tr>
</tbody>
</table>

**C.** Is your organization publicly traded or privately held? If your organization is publicly traded, identify its stock ticker symbol.

**D.** Point of Contact regarding this survey:

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Phone Number</th>
<th>E-mail Address</th>
<th>State</th>
</tr>
</thead>
</table>

**Comments:**
## Section 1b: Organization Information (continued)

### Identify and rank in descending order all entities that directly or indirectly own or have beneficial ownership of five percent or more of your organization (including parent companies and others):  

<table>
<thead>
<tr>
<th>Entity Name</th>
<th>Percent of Company Held</th>
<th>Street Address</th>
<th>City</th>
<th>State/Region</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide the following identification codes (see definitions), as applicable, to this facility.

<table>
<thead>
<tr>
<th>Data Universal Numbering System (DUNS) Code(s)</th>
<th>NAICS (6-digit) Code(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Find DUNS numbers at:  
http://fedgov.dnb.com/webfor

Find NAICS codes at:  
http://www.census.gov/epcd/www/naics.html

### Indicate if your organization qualifies as any of the following types of business:

1. A small business enterprise (as defined by the Small Business Administration)  
2. 8(a) Firm (as defined by the Small Business Administration)  
3. A historically underutilized business zone (HUBZone)  
4. A minority-owned business  
5. A woman-owned business  
6. A veteran-owned or service-disabled veteran-owned business

### Comments:

---

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
### Commercial Market Segments

From the list below, estimate the percentage of this facility's bare circuit board sales attributable to each COMMERCIAL end use.

<table>
<thead>
<tr>
<th>Commercial End Use</th>
<th>% of Bare Circuit Board Sales</th>
<th>Commercial End Use</th>
<th>% of Bare Circuit Board Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace</td>
<td></td>
<td>Industrial Electronics</td>
<td></td>
</tr>
<tr>
<td>Automotive</td>
<td></td>
<td>Medical/Healthcare</td>
<td></td>
</tr>
<tr>
<td>Communications</td>
<td></td>
<td>Marine (surface and underwater)</td>
<td></td>
</tr>
<tr>
<td>Computers/Business Equipment</td>
<td></td>
<td>Space</td>
<td></td>
</tr>
<tr>
<td>Consumer Goods</td>
<td></td>
<td>Other</td>
<td>(specify here)</td>
</tr>
</tbody>
</table>

### Defense Market Segments

From the list below, estimate the percentage of this facility's bare circuit board sales attributable to each DEFENSE end use.

<table>
<thead>
<tr>
<th>Defense End Use</th>
<th>% of Bare Circuit Board Sales</th>
<th>Defense End Use</th>
<th>% of Bare Circuit Board Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace</td>
<td></td>
<td>Missiles</td>
<td></td>
</tr>
<tr>
<td>Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)</td>
<td></td>
<td>Marine (surface and underwater)</td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td></td>
<td>Space</td>
<td></td>
</tr>
<tr>
<td>Ground Vehicles</td>
<td></td>
<td>Other</td>
<td>(specify here)</td>
</tr>
</tbody>
</table>

**Comments:**

---

*BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act*
### Mergers, Acquisitions, Divestitures

Identify and describe your organization's five most recent mergers, acquisitions, and divestitures, if applicable.

<table>
<thead>
<tr>
<th>Organization Name</th>
<th>Type of Activity</th>
<th>Country</th>
<th>Year</th>
<th>Primary Objective</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

#### Business Confidential - Per Section 705(d) of the Defense Production Act

---

### Joint Ventures

Identify your organization’s current joint venture relationships, including public/private R&D partnerships. Be sure to explain the joint venture’s purpose (e.g. patent licensing, co-production, product integration, after-market support, etc.).

<table>
<thead>
<tr>
<th>Organization/Entity Name</th>
<th>Country</th>
<th>Year Initiated</th>
<th>Primary Purpose of Relationship</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Section 3a: Customers

#### A. Select the primary method this facility uses to find business opportunities with the U.S. Government:

<table>
<thead>
<tr>
<th>Explain</th>
<th>-Yes/No-</th>
<th>Explain</th>
</tr>
</thead>
</table>

#### B. Since 2012 has this facility rejected business opportunities due to any of the following?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient order frequency</td>
<td></td>
</tr>
<tr>
<td>Insufficient dollar value of job</td>
<td></td>
</tr>
<tr>
<td>Insufficient dollar value of recurring business opportunity</td>
<td></td>
</tr>
<tr>
<td>Complexity of job</td>
<td></td>
</tr>
<tr>
<td>Customer credit rating</td>
<td></td>
</tr>
<tr>
<td>Additional work not needed</td>
<td></td>
</tr>
<tr>
<td>Other criteria (specify here)</td>
<td></td>
</tr>
</tbody>
</table>

#### C. Identify this facility's top 5 U.S. and top 5 non-U.S. direct customers by sales for the past four years. A direct customer is the immediate entity to which you sell your products/services. Customers can include other business units/divisions within your parent organization. Indicate the type of customer and their location.

**Top U.S.-Based Customers**

<table>
<thead>
<tr>
<th>Customer Name</th>
<th>Type of Customer</th>
<th>Primary End Use</th>
<th>Customer City</th>
<th>Customer State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Top Non-U.S.-Based Customers**

<table>
<thead>
<tr>
<th>Customer Name</th>
<th>Type of Customer</th>
<th>Primary End Use</th>
<th>Customer City</th>
<th>Customer Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**
### Section 3b: Competitors

For each of the following factors, indicate whether bare circuit board manufacturers located inside the U.S. or outside the U.S. possess the competitive advantage.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Location with Advantage</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Compliance Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building Space Costs</td>
<td>U.S.</td>
<td></td>
</tr>
<tr>
<td>R&amp;D Costs</td>
<td>Non-U.S.</td>
<td></td>
</tr>
<tr>
<td>Supply of Skilled Workers</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Export Controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Finished Board Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced Process Variability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Yield</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>(specify here)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>(specify here)</td>
<td></td>
</tr>
</tbody>
</table>

Identify your organization's leading U.S. and non-U.S. competitors in the manufacture of bare circuit boards, and select their primary competitive attribute.

#### Top U.S. Competitors

<table>
<thead>
<tr>
<th>Competitor Name</th>
<th>State</th>
<th>Primary Competitive Attribute</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Top Non-U.S. Competitors

<table>
<thead>
<tr>
<th>Competitor Name</th>
<th>Country</th>
<th>Primary Competitive Attribute</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

*BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act*
# Section 4a: Participation in USG Programs

## USG Agency Support

Identify the USG agencies supported by this facility since 2012. If you support an agency not already listed, indicate which agency in the "Other" box.

<table>
<thead>
<tr>
<th>USG Agency</th>
<th>USG Agency Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Air Force</td>
<td>Department of Homeland Security (DHS)</td>
</tr>
<tr>
<td>U.S. Army</td>
<td>National Aeronautics &amp; Space Administration (NASA)</td>
</tr>
<tr>
<td>U.S. Navy</td>
<td>National Oceanic &amp; Atmospheric Administration (NOAA)</td>
</tr>
<tr>
<td>U.S. Marine Corps</td>
<td>Department of Energy (DOE)</td>
</tr>
<tr>
<td>U.S. Intelligence Community</td>
<td>Missile Defense Agency (MDA)</td>
</tr>
<tr>
<td>(such as CIA, NGA, NRO, NSA)</td>
<td></td>
</tr>
</tbody>
</table>

## USG Program Identification

Estimate the total number of USG programs this facility has directly or indirectly supported since 2012.

B. Identify the USG programs this facility has supported since 2012, and indicate which types of bare circuit boards this facility has manufactured for each program.

<table>
<thead>
<tr>
<th>USG Program Name</th>
<th>U.S. Government Agency</th>
<th>Bare Circuit Board Type Supporting USG Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rigid</td>
</tr>
<tr>
<td>1</td>
<td>U.S. Air Force</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>U.S. Army</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>U.S. Navy</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>U.S. Marine Corps</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>U.S. Intelligence Community (such as CIA, NGA, NRO, NSA)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DHS - Department of Homeland Security</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>NASA - National Aeronautics &amp; Space Administration</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NOAA - National Oceanic &amp; Atmospheric Administration</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>DOE - Department of Energy</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>MDA - Missile Defense Agency</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>DARPA - Defense Advanced Research Projects Agency</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>USDA - Department of Agriculture</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>DOC - Department of Commerce</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>HHS - Department of Health and Human Services</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>State Department</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Justice Department</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Transportation Department</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>EPA - Environmental Protection Agency</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>FCC - Federal Communications Commission</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>NRC - Nuclear Regulatory Commission</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VA - Department of Veterans Affairs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>White House</td>
<td></td>
</tr>
</tbody>
</table>

Comments: 

*BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act*
### Section 4b: USG Interactions

**A.** If this facility's bare circuit board manufacturing supports USG programs, whether directly or indirectly, are the associated manufacturing lines integrated with, or separate from, its commercial manufacturing lines?

<table>
<thead>
<tr>
<th>Explain</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>Separate</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

**B.** Identify impacts that a sudden change in direct and/or indirect US. Government defense demand for electronic products containing bare circuit boards would likely have on your organization and provide an explanation where applicable.

<table>
<thead>
<tr>
<th>Business Operation</th>
<th>Impact of sudden DECREASE in USG Defense Demand</th>
<th>Impact of sudden INCREASE in USG Defense Demand</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Expenditures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research &amp; Development Expenditures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation in USG Contracts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**B.** Other Operations Costs

<table>
<thead>
<tr>
<th>Other</th>
<th>(specify here)</th>
<th>(specify here)</th>
</tr>
</thead>
</table>

### Comments:

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
### Section 5a: Manufacturing Capabilities

#### A. Identify the Types of Bare Circuit Boards that This Facility is Currently Capable of Manufacturing:

<table>
<thead>
<tr>
<th>Bare Circuit Board Type</th>
<th>Tin-Lead</th>
<th>Lead-Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid Conventional Board (single-sided or double-sided)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rigid Multilayer Board</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rigid High Speed Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rigid High Frequency Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rigid Microwave Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flexible Conventional Board (single-sided or double-sided)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flexible Multilayer Board</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flexible High Speed Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flexible High Frequency Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flexible Microwave Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rigid-Flex Hybrid Boards</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Integrated Circuit Package Substrates</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

#### B. What is the Minimum Inner Layer (Core) Thickness of Circuit Board Components that This Facility Can Produce?

- **Trace Width (in inches)**
  - 0.25 oz copper
  - 0.5 oz copper
  - 1 oz copper
  - 2 oz copper
  - 3-5 oz copper
  - 6-10 oz copper
  - 10+ oz copper

<table>
<thead>
<tr>
<th>Copper Weight</th>
<th>External Layer: Standard</th>
<th>0.002&quot;</th>
<th>0.003&quot;</th>
<th>0.004&quot;</th>
<th>0.005&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>External Layer: Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal Layer: Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal Layer: Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### C. Does This Facility Manufacture Printed Electronics (PE)?

- If yes, identify the PE business activities this facility engages in:
  - R&D Only
  - Limited Production
  - Full Production
  - Other (explain)

- What is the maximum bare circuit board thickness that this facility can achieve?

#### D. For Each Type of Bare Circuit Board Layer Listed Below, Identify This Facility’s Standard and Minimum Trace Widths, Based on Specified Copper Conductor Weights:

<table>
<thead>
<tr>
<th>Trace Width (in inches)</th>
<th>0.25 oz copper</th>
<th>0.5 oz copper</th>
<th>1 oz copper</th>
<th>2 oz copper</th>
<th>3-5 oz copper</th>
<th>6-10 oz copper</th>
<th>10+ oz copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Layer: Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Layer: Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Layer: Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Layer: Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### E. For Each Type of Bare Circuit Board Layer Listed Below, Identify This Facility’s Standard and Minimum Space Widths, Based on Specified Copper Conductor Weights:

<table>
<thead>
<tr>
<th>Space Width (in inches)</th>
<th>0.25 oz copper</th>
<th>0.5 oz copper</th>
<th>1 oz copper</th>
<th>2 oz copper</th>
<th>3-5 oz copper</th>
<th>6-10 oz copper</th>
<th>10+ oz copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Layer: Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Layer: Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Layer: Standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Layer: Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: 

---

B. BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

---

PDF FOR REFERENCE
SUBMIT EXCEL VERSION ONLY
Section 5b: Manufacturing Capabilities (continued)

A. Identify the bare circuit board manufacturing processes that this facility is capable of employing:

<table>
<thead>
<tr>
<th>Process</th>
<th>Capable of Using</th>
<th>Currently Use</th>
<th>Process</th>
<th>Capable of Using</th>
<th>Currently Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo imaging</td>
<td></td>
<td></td>
<td>Thermal management structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct imaging</td>
<td></td>
<td></td>
<td>Automated electroless copper plating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screen printing</td>
<td></td>
<td></td>
<td>Automated electrolytic copper plating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controlled drilling/milling</td>
<td>Yes</td>
<td></td>
<td>Direct metallization plating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser ablation</td>
<td>No</td>
<td></td>
<td>Hot air solder level tin-lead</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully additive plating</td>
<td></td>
<td></td>
<td>Hot air solder level lead-free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z-axis interconnect technology</td>
<td></td>
<td></td>
<td>LPI solder mask</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded devices (e.g. resistors, capacitors, etc.)</td>
<td></td>
<td></td>
<td>Dry film solder mask</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opto-electronic structures</td>
<td></td>
<td></td>
<td></td>
<td>Other</td>
<td>(specify here)</td>
</tr>
</tbody>
</table>

B. Identify this facility's maximum capability for each of the following bare circuit board production factors:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Maximum per Board</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit layers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequential laminations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impedance structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stacked micro vias</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staggered micro vias</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Identify where the bare circuit board via fill and planarization manufacturing activities are performed for this facility:

<table>
<thead>
<tr>
<th>Process Method</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td></td>
</tr>
<tr>
<td>Automatic</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td></td>
</tr>
<tr>
<td>Neither</td>
<td></td>
</tr>
</tbody>
</table>

D. Identify which of the following processes associated with via structures this facility is capable of performing:

<table>
<thead>
<tr>
<th>Process</th>
<th>Maximum aspect ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etchback</td>
<td></td>
</tr>
<tr>
<td>Chemical smear removal</td>
<td></td>
</tr>
<tr>
<td>Micro-via solid copper fill</td>
<td></td>
</tr>
</tbody>
</table>

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 5c: Manufacturing Standards

Identify the standards that this facility currently employs and indicate whether you have a formal certification or apply the standards informally.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Use</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL-PRF 55110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIL-PRF 50884</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIL-PRF 31032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO 9001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS 9100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NADCAP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 1071</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC 6018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**A.** Does this facility have an active technical review board?

**B.** Explain:

**C.** Identify the primary final circuit board inspection method this facility uses to assure that manufactured products meet performance requirements.

**D.** Identify the forms of testing that this facility uses in manufacturing to assure performance and adherence to operational requirements.

**E.** Does this facility use Statistical Process Control with TrueChem or equivalent software specifically to control and automate the management of chemistries, coatings, and associated bare circuit board production processes?

**F.** Does this facility employ Material Requirements Planning (MRP) software in the operation of its bare circuit board manufacturing facilities in the U.S.?

**Comments:**

---

*BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act*
Section 5d: Manufacturing Production & Capacity

For each of the years 2012-2015, estimate the average weekly number of inner layers (cores) and completed circuit board panels that this facility manufactured:

**A. Inner Layer (Core):**
A sheet of copper clad dielectric with one or both sides bearing circuit patterns.

**B. Panel:**
(1) a double-sided or single-sided rigid structure (double-sided or single-sided panel) or
(2) two or more inner cores laminated together forming a multilayered, rigid structure (multilayer panel).

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Weekly Inner Layers (Cores) Manufactured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Weekly Panels Manufactured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Identify the bare circuit board panel sizes that this facility can produce with its current manufacturing equipment:

<table>
<thead>
<tr>
<th>Panel Size</th>
<th>24x36</th>
<th>24x30</th>
<th>21x24</th>
<th>18x24</th>
<th>12x24</th>
<th>12x18</th>
<th>9x12</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Estimate the 2015 rated weekly manufacturing capacity of this facility in units:

<table>
<thead>
<tr>
<th>Inner Layers (Cores)</th>
<th>Panels</th>
</tr>
</thead>
</table>

- How many 8-hour production shifts does this facility typically operate per day?
- How many 8-hour production shifts per day COULD this facility operate practically?
- How many 8-hour front-end engineering shifts per day COULD this facility operate practically?

**D.**
Estimate this facility's average manufacturing utilization rate for each of the years 2012-2015, as a percentage of production possible under a 7 day-per-week, 24-hour-per-day operation.

- Note: a 100% utilization rate equals full operation with no downtime beyond that necessary for maintenance

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**E.**
Examples: Assuming little maintenance downtime, one 8-hour shift, 5 days per week is approximately 25% capacity utilization; two 8-hour shifts, 7 days per week is approximately 65% capacity utilization.

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**F.**
Estimate how many weeks it would take to raise this facility’s production from current levels to 100% capacity utilization:

- If this facility already operates at 100% capacity utilization, respond with a "0"

<table>
<thead>
<tr>
<th>Scenario</th>
<th>100%</th>
<th>150%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**G.**
Identify which of the factors below would limit this facility's ability to raise its bare circuit board manufacturing utilization rate to 100% (maximum current capacity) and to 150% (50% increase from current maximum capacity) to meet a surge in demand.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Scenario:</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Amount of equipment</td>
<td>100%</td>
<td>150%</td>
</tr>
<tr>
<td>2 Availability of equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Manufacturing space</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Availability or cost of workforce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Quality control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Availability of input materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Other (specify in explanation)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 5e: Manufacturing Production & Capacity (continued)

#### How does this facility anticipate the range of bare circuit board product lines it manufactures will change by 2020?

<table>
<thead>
<tr>
<th>Board Type</th>
<th>Anticipated Change</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid Conventional Board (single-sided or double-sided)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigid Multilayer Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigid High Speed Boards</td>
<td>Increase</td>
<td></td>
</tr>
<tr>
<td>Rigid High Frequency Boards</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td>Rigid Microwave Boards</td>
<td>Decrease</td>
<td></td>
</tr>
<tr>
<td>Flexible Conventional Board (single-sided or double-sided)</td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td>Flexible Multilayer Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible High Speed Boards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible High Frequency Boards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible Microwave Boards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigid-Flex Hybrid Boards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated Circuit Package Substrates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### How does this facility anticipate its front-end engineering processing capabilities will change by 2020?

<table>
<thead>
<tr>
<th>End Use</th>
<th>Anticipated Change</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>Increase</td>
<td></td>
</tr>
<tr>
<td>Defense</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not Applicable</td>
<td></td>
</tr>
</tbody>
</table>

1. Does this facility have its own staff on site to perform front-end engineering for manufacturing bare circuit boards?
2. Does this facility perform front-end engineering for manufacturing bare circuit boards as a service to other companies that may have bare circuit boards manufactured elsewhere?
   - Does this facility outsource any front-end engineering for bare circuit board products manufactured at this facility?
     - If yes, does your company notify customers in advance that it outsources front-end engineering for manufacturing bare circuit boards?
     - If this facility outsources front-end engineering for bare circuit board products, indicate the country or countries (including the United States) to which this service is outsourced:

<table>
<thead>
<tr>
<th>End Use</th>
<th>Yes/No-</th>
<th>Country 1</th>
<th>Country 2</th>
<th>Country 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defense</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Identify the three biggest factors causing production bottlenecks at this facility.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated optical inspection (AOI)</td>
<td></td>
</tr>
<tr>
<td>Drilling</td>
<td></td>
</tr>
<tr>
<td>Electroless plating</td>
<td></td>
</tr>
<tr>
<td>Electrolytic plating</td>
<td></td>
</tr>
<tr>
<td>Electrical test</td>
<td></td>
</tr>
<tr>
<td>Etching</td>
<td></td>
</tr>
<tr>
<td>Front end engineering</td>
<td></td>
</tr>
<tr>
<td>Inner layer pre-treatment</td>
<td></td>
</tr>
<tr>
<td>Imaging</td>
<td></td>
</tr>
<tr>
<td>Lamination</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

Comments:

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
For each of the inputs below, state whether you have experienced sourcing problems and identify the principal manufacturers of each material that this facility uses in manufacturing bare circuit boards.

<table>
<thead>
<tr>
<th>Material</th>
<th>Total Number of Manufacturers Used</th>
<th>Sourcing Problems Experienced Supply Chain Disruptions Since 2012</th>
<th>Two Principal Manufacturer Names</th>
<th>Country of Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminate for use in rigid conventional boards</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminate for use in rigid multilayer boards</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminate for use in rigid high speed, high frequency, and microwave boards</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminate for use in flex boards</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminate for use in rigid-flex boards</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper foil</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other foils</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded passives, formed, resistors, and capacitors (active or passive) - tin-lead</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded passives, formed, resistors, and capacitors (active or passive) - lead free</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through-hole and via preparation for plating material</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrolytic plating material</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via fill, conductive, and non-conductive material</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solder mask</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish materials</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solder</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Etchant</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drill bits</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 6b: Materials & Equipment (continued)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>If this facility were no longer able to purchase circuit board laminate from your current suppliers, for how many weeks could you continue normal operations?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>How many weeks would it take this facility to obtain material from a new supplier of laminate?</td>
<td></td>
</tr>
<tr>
<td>A. 3</td>
<td>Does the reduction in the number of companies in the U.S. that manufacture circuit board laminates and other circuit board-related materials create material supply problems for this facility?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explain:</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>How confident are you that this facility could obtain on a timely basis the material necessary to rapidly ramp up bare circuit board production in the event of a national emergency?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explain:</td>
<td>Very confident</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Somewhat confident</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not confident</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Would not be able to</td>
</tr>
</tbody>
</table>

#### A.
Which statement best describes this facility’s general method for maintaining inventory levels of laminate and related materials required for the production of circuit boards?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B.</td>
<td>Minimize on-hand inventory of circuit board production materials. Maintain extra inventory as a buffer against unexpected delays in material shipments and unanticipated new production orders.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explain:</td>
<td></td>
</tr>
</tbody>
</table>

Does this facility use either of the following practices for assuring the availability of circuit board-related materials?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C. 1</td>
<td>On-site stocking agreements through which distributors/manufacturers keep a quantity of materials at this facility.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Local stocking agreements through which distributors/manufacturers maintain supply warehouses in close proximity to this facility.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explain:</td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

---

*BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act*
### Section 6c: Materials & Equipment (continued)

From the list below identify how many of each type of equipment this facility has. Then, estimate overall average age, and indicate your primary concern about continued/future use of this equipment.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Number of Functioning Units On Site</th>
<th>Estimated Average Age (in years)</th>
<th>Primary Concern</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo film processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photo resist application</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photo resist exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photo resist exposure-laser</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photo resist exposure-LED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop etch &amp; strip equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic optical inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner layer treatment &amp; layup</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling - mechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling - laser</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desmear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electroless copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrolytic copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical cleaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solder mask</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final finish</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legend print</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality control measurement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via fill</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U.S.</th>
<th>Non-U.S.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. Has this facility had trouble obtaining parts for U.S. or non-U.S. equipment?

Has this facility had trouble obtaining service on U.S. or non-U.S. equipment?

B. Are there bare circuit board products that this facility is unable to manufacture due to the limitations of installed equipment?

Have you had or do you anticipate having difficulty obtaining new equipment for manufacturing tin-lead bare circuit boards?

C. Explain:

Comments:

---

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 6d: Materials & Equipment (continued)

#### A. Between 2012 and 2015, did this facility encounter product failures that are suspected or confirmed to be attributed to counterfeit materials used in building bare circuit boards?

If so, identify the types of circuit board materials that were suspected or confirmed to be counterfeit products and explain the impact of the counterfeit.

<table>
<thead>
<tr>
<th>Material</th>
<th>Suspected/Confirmed</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminate</td>
<td>Confirmed</td>
<td>Explain</td>
</tr>
<tr>
<td>Soldermask</td>
<td>Both</td>
<td>Explain</td>
</tr>
<tr>
<td>Other (specify here)</td>
<td>No</td>
<td>Explain</td>
</tr>
</tbody>
</table>

#### B. Does this facility buy materials for the manufacture of bare circuit boards from sources other than the original manufacturer or its authorized distributor?

If so, what practices do you regularly use to verify that the materials are genuine and perform to specifications?

- Systematic testing of inventory
- Confirm production lots and production dates with the original manufacturer
- Check authenticity of standards organization certification labels/trademarks

Other (specify here)

Other (specify here)

Comments:

---

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
## Section 7: Sales

Provide this facility's sales information for the 2012-2015 to U.S. and non-U.S. customers.

- **Note:** "U.S." means U.S. domestic sales; "Non-U.S." means export sales from U.S. locations.
- Government sales include both direct and indirect sales to government customers. All sales with government end uses should be reported as government sales.

### Source of Sales Data:
- Facility Division/Business Unit
- Corporate/Whole Organization

### Reporting Schedule:
- Calendar Year
- Fiscal Year

### Record in $ Thousands, e.g. $12,000.00 = survey input $12

<table>
<thead>
<tr>
<th>A. Total Sales (in $)</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Government Sales [as a % of line A]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. All Circuit Board-Related Sales - including design, manufacture, and assembly (in $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Circuit Board-Related Government Sales [as a % of line B]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Bare Circuit Board Manufacturing Sales - excluding design and assembly (in $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Circuit Board Government Sales [as a % of line C]</td>
</tr>
</tbody>
</table>

### Comments:

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
## Section 8: Financials

Provide the following financial line items for your facility/organization below.

Note: Facility level data is preferred. If you do not keep this information at a location level, provide data at the closest level available.

### Income Statement (Select Line Items)

<table>
<thead>
<tr>
<th>Source of Income Statement Items:</th>
<th>Reporting Schedule:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record $ in Thousands, e.g. $12,000.00 = survey input of $12</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Net Sales (and other revenue)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Cost of Goods Sold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total Operating Income (Loss)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Earnings Before Interest and Taxes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Net Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Balance Sheet (Select Line Items)

<table>
<thead>
<tr>
<th>Source of Balance Sheet Items:</th>
<th>Reporting Schedule:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record $ in Thousands, e.g. $12,000.00 = survey input of $12</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Cash</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Inventories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total Current Assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Total Assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Total Current Liabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Total Liabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Retained Earnings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Total Owner's Equity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Total Assets must equal Total Liabilities plus Total Owner's Equity

Comments:  

---

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 9a: Research & Development

**A.** Does this facility/organization conduct research and development (R&D)?

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

If No, proceed to Section 10.

In Question B, record this facility's total dollar R&D expenditure and type of R&D expenditure for each of the years 2012 to 2015. In Question C, identify this facility's R&D funding sources, by percent of total R&D dollars sourced.

Note: Facility level data is preferred. If you do not keep this information at a facility level, provide data at the closest level available.

**Source of R&D Data:**

**Record $ in Thousands, e.g. $12,000.00 = survey input of $12**

### B. Total R&D Expenditures

1. Total R&D Expenditures
2. Basic Research (as a percent of B1)
3. Applied Research (as a percent of B1)
4. Product/Process Development (as a percent of B1)
5. Total of 2, 3, and 4 (must equal 100%)

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

6. Bare Circuit Board R&D Expenditures (as a percent of B1)
7. Defense-Related Bare Circuit Board R&D Expenditures (as a percent of B1)

**Record $ in Thousands, e.g. $12,000.00 = survey input of $12**

### C. Total R&D Funding Sources

1. Total R&D Funding Sources
2. Internal/Self-Funded/IRAD (as a percent of C1)
3. Total Federal Government (as a percent of C1)
4. Total State and Local Government (as a percent of C1)
5. Universities - Public and Private (as a percent of C1)
6. U.S. Industry, Venture Capital, Non-Profit (as a percent of C1)
7. Non-U.S. Investors (as a percent of C1)
8. Other (specify here)

**Comments:**

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 9b: Research & Development (continued)

#### Identify this facility/organization's anticipated top R&D priorities over the next five years and provide a brief explanation.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ultra smooth copper foil</td>
</tr>
<tr>
<td>2</td>
<td>Development of very thin unsupported dielectrics</td>
</tr>
<tr>
<td>3</td>
<td>Enhanced solid copper via fill methods</td>
</tr>
<tr>
<td>4</td>
<td>Sub-10 micrometer photolithography, etchants</td>
</tr>
<tr>
<td>5</td>
<td>Printed electronics (additive, 3-D, etc.)</td>
</tr>
</tbody>
</table>

#### Identify the key factors driving this facility's investment in research and development and explain how these factors shape this facility's research and development projects.

<table>
<thead>
<tr>
<th>Factor</th>
<th>-Yes/No-</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need for competitive advantage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry roadmap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>(specify here)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>(specify here)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>(specify here)</td>
<td></td>
</tr>
</tbody>
</table>

#### From 2012-2015, were your organization's R&D expenditures adversely impacted by reductions in U.S. Government defense spending?

**Explain:**

#### Are there specific R&D areas related to bare circuit board manufacturing that DOD could support to improve board performance?

**Explain:**

#### What advanced bare circuit board-related technologies should DOD support in order to better enable manufacturers to meet future national security requirements?

<table>
<thead>
<tr>
<th>Explain</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
Section 10: Capital Expenditures

Record this facility's capital expenditures corresponding to the select categories below.

Note: Facility level data is preferred. If you do not keep this information at a location level, provide data at the closest level available.

<table>
<thead>
<tr>
<th>Source of Capital Expenditure Data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Expenditure Reporting Schedule:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capital Expenditure Category</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Total Capital Expenditures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Machinery, Equipment, and Vehicles [as a % of A]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 IT, Computers, Software [as a % of A]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Land, Buildings, and Leasehold Improvements [as a % of A]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Other (specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Other (specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lines 1 through 5 must total 100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>6 Bare circuit board-related capital expenditures [as a % of A]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B From 2012-2015, were your organization's bare circuit board-related capital expenditures adversely impacted by reductions in U.S. Government defense spending?

Explain:

C Identify your facility/organization's anticipated top bare circuit board-related capital expenditure priorities over the next five years and provide a brief explanation.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Expanded facility</td>
</tr>
<tr>
<td>4</td>
<td>Equipment for new technologies</td>
</tr>
<tr>
<td>5</td>
<td>Equipment for existing technologies</td>
</tr>
<tr>
<td>6</td>
<td>IT/computers/software</td>
</tr>
<tr>
<td>7</td>
<td>Other</td>
</tr>
</tbody>
</table>

Business Confidential - Per Section 705(d) of the Defense Production Act
Record the total number of full time equivalent (FTE) employees in your U.S.-based operations for the 2012-2015 period. Then, estimate the percentage of these employees that perform the occupations indicated in part A, lines a-i.

Note: Facility level data is preferred. If you do not keep this information at a location level, provide data at the closest level available.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Difficulty</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic Arts Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM Software - Job Tooling Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imaging Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silk Screening Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plating Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Testing Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Drilling Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser Drilling Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing Tech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Identify the key workforce issues you anticipate in the next five years.

<table>
<thead>
<tr>
<th>Issue</th>
<th>-Yes/No-</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding U.S. citizens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding qualified workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding experienced workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding workers able to get security clearances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attracting workers to location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant portion of workforce retiring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee turnover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
## Section 11b: Workforce (continued)

A. What percentage of this facility’s technical staff do you expect to retire within the next five years? [ ]

A. What percentage of this facility’s technical staff do you expect to have to replace over the next five years? [ ]

Explain: [ ]

First, estimate the total number of employees you have with each level of work experience and estimate the percentage that are U.S. citizens.

Then, for each technical role, estimate the number of employees you have with each level of work experience.

<table>
<thead>
<tr>
<th>Applicable Working Experience</th>
<th>Over 20 Years</th>
<th>11-20 Years</th>
<th>6-10 Years</th>
<th>Five or Fewer Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Employees</td>
<td># of Employees</td>
<td>% U.S. Citizens</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Double counting is permitted for this section. For example, if an employee serves as both a mechanical drilling tech and a laser drilling tech, the employee would be included in both lines.

<table>
<thead>
<tr>
<th>Experience</th>
<th>Over 20 Years</th>
<th>11-20 Years</th>
<th>6-10 Years</th>
<th>Five or Fewer Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic Arts Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Engineer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM Software - Job Tooling Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imaging Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silk Screening Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plating Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Testing Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Drilling Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser Drilling Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing Tech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: [ ]

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 12a: Competitive Factors

#### A. What is the primary, if any, significant change in operations that is expected at this facility in the next five years?

Explain:

#### B. 1 Have recent changes in environmental control regulations adversely affected this facility's capability to compete against circuit board manufacturers in other countries?

Explain:

#### B. 2 Will environmental regulations force this facility to cease manufacturing tin-lead circuit boards?

If yes, what year is this facility expected to cease producing tin-lead circuit boards?

**Comments:**

#### B. 3 Do environmental regulations cause this facility to keep smaller quantities of circuit board manufacturing materials in inventory than what you might otherwise consider optimal?

Explain:

#### C. Indicate whether the following factors affect this facility's interest in USG business.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Reduce Interest in USG Business</th>
<th>May Cause Facility to Stop Producing for USG</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperwork/Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow Payment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Production Lots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient Profit Margin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrequent Orders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual Property Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-off orders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrequent Orders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify here)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### D. Indicate how DOD requirements to use MIL-PRF-31032 standards affect your costs relative to other existing standards?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Estimated Change Relative to MIL-P-50884C</th>
<th>Estimated Change Relative to IPC-6012 Class 3</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage direct change in fixed costs per slash sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change in recurring costs for maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change in administrative cost of compliance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

---

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act
### Section 12b: Competitive Factors (continued)

**To what extent is this facility's continued ability to manufacture bare circuit boards for USG customers dependent on the viability of your commercial circuit board business?**

Explain

**To what extent is this facility's continued ability to manufacture bare circuit boards for commercial customers dependent on the viability of your USG business?**

Explain

**Is the return-on-investment (ROI) associated with this facility's DEFENSE-RELATED bare circuit board manufacturing business sufficient relative to capital requirements and business risk?**

Explain

**Is the return-on-investment (ROI) associated with this facility's COMMERCIAL bare circuit board manufacturing business sufficient relative to capital requirements and business risk?**

Explain

**What level of overall industry consolidation do you expect to occur in the U.S. bare circuit board industry in the next five years?**

Explain

**What two key factors do you see driving such a consolidation?**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved production efficiency</td>
<td>Cost reduction</td>
</tr>
<tr>
<td>Excess production capacity</td>
<td>Not technologically competitive</td>
</tr>
<tr>
<td>Diminishing commercial orders</td>
<td>Shrinking USG orders</td>
</tr>
<tr>
<td>Increased foreign competition</td>
<td>Larger companies possess market advantages</td>
</tr>
</tbody>
</table>

**What level of foreign acquisition of U.S. bare circuit board manufacturers do you expect in the next five years?**

Explain

**Which of the following impacts do you anticipate from consolidation in the number of U.S. bare circuit board manufacturing facilities?**

<table>
<thead>
<tr>
<th>Impact</th>
<th>-Yes/No-</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fewer U.S. materials manufacturers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater dependence on non-U.S. materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher material costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pricing advantage for larger board manufacturers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small companies less able to compete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced domestic board capability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrinkage in manufacturing workforce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased market share for non-U.S. companies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher prices for bare board customers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
### Section 12c: Competitive Factors (continued)

What impact would each of the following potential USG actions have on your business?

<table>
<thead>
<tr>
<th>Action</th>
<th>Expected Impact on Organization</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased funding of targeted bare circuit board manufacturing technology R&amp;D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOD requirement that electronic systems (not ITAR controlled) use circuit boards made in manufacturing facilities located in the U.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOD adds circuit board laminate and related materials to the Defense National Stockpile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USG requirement that circuit boards produced for critical systems be manufactured with laminate and related materials made in the U.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOD requirement for designated types of defense systems to use bare circuit boards manufactured in the U.S. by certified &quot;trusted&quot; suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOD requirement that bare circuit board manufacturers of products for designated defense systems be registered on the Qualified Manufacturers List (QML) and/or Qualified Products List (QPL)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other (specify here)  
Other (specify here)  

Comments:

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
### Section 13a: Cyber Security

#### A. Does your organization’s internal network connect to the Internet?

<table>
<thead>
<tr>
<th>Internal Network (drop-down)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

#### B. Indicate who is responsible for your organization’s internal IT networks:

<table>
<thead>
<tr>
<th>Indicate who is responsible for your organization’s internal IT networks:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

#### B. Indicate who is responsible for your organization’s external IT networks:

<table>
<thead>
<tr>
<th>Indicate who is responsible for your organization’s external IT networks:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

#### Does this facility have defined, structured methods for actively protecting the following types of Commercially Sensitive Information (see definitions)?

<table>
<thead>
<tr>
<th>Commercially Sensitive Information (CSI) Type</th>
<th>-Yes/No-</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer/client information</td>
<td></td>
<td>Internal IT Department</td>
</tr>
<tr>
<td>Financial information and records</td>
<td></td>
<td>Internal IT Department and U.S. external provider(s)</td>
</tr>
<tr>
<td>Human resources information/employee data</td>
<td></td>
<td>Internal IT Department and non-U.S. external provider(s)</td>
</tr>
<tr>
<td>Information subject to export control regulations (EAR and/or ITAR)</td>
<td></td>
<td>Only U.S. external provider(s)</td>
</tr>
</tbody>
</table>

#### C. Intellectual property related information

<table>
<thead>
<tr>
<th>Intellectual property related information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal communications including negotiation points, merger and acquisition plans, and/or corporate strategy</td>
</tr>
<tr>
<td>Manufacturing and production line information</td>
</tr>
<tr>
<td>Patent and trademark information</td>
</tr>
<tr>
<td>Regulatory/compliance information</td>
</tr>
<tr>
<td>Research and development (R&amp;D) related information</td>
</tr>
<tr>
<td>Supply chain and sourcing information</td>
</tr>
</tbody>
</table>

#### Comments:

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

---

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
## Section 13b: Cyber Security (continued)

### A. Have recent cyber incidents across the marketplace caused your organization to increase its information security budget?

### B. Estimate the percentage of your organization's commercially sensitive information that is stored with:

<table>
<thead>
<tr>
<th>External Cloud Service Providers</th>
<th>External Data Storage Providers</th>
</tr>
</thead>
</table>

Does your organization restrict or prohibit your external cloud service or external data storage provider(s) from storing commercially sensitive information outside of the U.S.?

### C. Indicate the level of impact each of the following types of events attributed to malicious cyber activity has had on this facility since 2012.

<table>
<thead>
<tr>
<th>Event</th>
<th>Impact Level</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>User idle time and lost productivity because of downtime or systems performance delays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disruption to normal operations because of system availability problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damage or theft of IT assets and infrastructure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incurred cost of damage assessment and remediation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business interruption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exfiltration of CSI data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The FBI encourages recipients to report information concerning suspicious or criminal activity to their local FBI field office or the FBI's 24/7 Cyber Watch (CyWatch). Field office contacts can be identified at [http://www.fbi.gov/contact-us/field](http://www.fbi.gov/contact-us/field). CyWatch can be contacted by phone at 855-292-3937 or e-mail at CyWatch@ic.fbi.gov. When available, each report submitted should include the date, time, location, type of activity, number of people, and type of equipment used for the activity, the name of the submitting company or organization, and a designated point of contact.

**Comments:**
## Section 14: Challenges and Outreach

Identify the issues that have or are expected to impact this facility.

In column A, identify all issues that currently are affecting your business in an adverse way or that are expected to do so in the future. In column B, rank your top five issues (one being the most important) by selecting numbers one through five, using each rank exactly once. In column C, provide an explanation for the relevant issues.

### Table of Issues

<table>
<thead>
<tr>
<th>Type of Issue</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aging equipment, facilities, or infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aging workforce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition - domestic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition - foreign</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counterfeit parts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyber security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental regulations/remediation - domestic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental regulations/remediation - foreign</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export controls/ITAR &amp; EAR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government acquisition process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government purchasing volatility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government regulatory burden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthcare costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health and safety regulations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual property/patent infringement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor availability/costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material input availability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obsolescence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pension costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to customers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to suppliers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualifications/certifications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of material inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in commercial demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in USG demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker/skills retention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(specify here)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other**

<table>
<thead>
<tr>
<th>Type of Issue</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(specify here)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are many federal and state government programs and services available to assist your organization to better compete in the global marketplace. If your organization would like more information regarding these government programs, select the specific areas of interest below. The Commerce Department will follow-up with your organization regarding your selections.

### Government Programs of Interest

<table>
<thead>
<tr>
<th>Area of Interest</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Improvement/Lean Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyber Security</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design for Assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design for Manufacturability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy and Environmentally Conscious Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export Assistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export Licensing (ITAR/EAR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government Procurement Guidelines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(specify here)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other**

<table>
<thead>
<tr>
<th>Area of Interest</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(specify here)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Business Confidential - Per Section 705(d) of the Defense Production Act
## Section 15: Certification

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct to the best of his/her knowledge. It is a criminal offense to willfully make a false statement or representation to any department or agency of the United States Government as to any matter within its jurisdiction (18 U.S.C.A. 1001 (1984 & SUPP. 1197))

Once this survey is complete, submit it via e-mail to: printedcircuitboards@bis.doc.gov. Be sure to retain a copy for your records and to facilitate any necessary edits or clarifications.

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Organization Name</th>
<th>Organization's Internet Address</th>
<th>Name of Authorizing Official</th>
<th>Title of Authorizing Official</th>
<th>E-mail Address</th>
<th>Phone Number and Extension</th>
<th>Date Certified</th>
</tr>
</thead>
</table>

In the box below, provide any additional comments or any other information you wish to include regarding this survey assessment.

How many hours did it take to complete this survey?

**BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act**
The U.S. Department of Commerce’s Office of Technology Evaluation is the focal point within the Department for conducting assessments of defense-related industries and technologies. The assessments are based on detailed industry-specific surveys used to collect information from U.S. companies and are conducted on behalf of the U.S. Congress, the Military Services, other U.S. Government agencies, industry associations, or other interested parties.

### Ongoing Assessments

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Air Force Industrial Supply Chain Sustainment Assessment</td>
<td>2020</td>
</tr>
<tr>
<td>U.S. Software Integration in Infrastructure Network Systems Assessment</td>
<td>2019</td>
</tr>
<tr>
<td>The Effect of Imports of Uranium on the National Security</td>
<td>2019</td>
</tr>
<tr>
<td>U.S. Integrated Circuit Design and Manufacturing Industry Assessment</td>
<td>2019</td>
</tr>
</tbody>
</table>

### Recent Assessments

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Air Force C-17 Aircraft Supply Chain Impact Assessment</td>
<td>2018</td>
</tr>
<tr>
<td>U.S. Rocket Propulsion Industrial Base Assessment</td>
<td>2018</td>
</tr>
<tr>
<td>The Effect of Imports of Steel on the National Security</td>
<td>Jan. 2018</td>
</tr>
<tr>
<td>The Effect of Imports of Aluminum on the National Security</td>
<td>Jan. 2018</td>
</tr>
<tr>
<td>U.S. Footwear Industrial Base Assessment</td>
<td>Summer 2017</td>
</tr>
<tr>
<td>U.S. Textile and Apparel Industrial Base Assessment</td>
<td>Summer 2017</td>
</tr>
<tr>
<td>U.S. Bare Printed Circuit Board Industry Assessment</td>
<td>2017</td>
</tr>
<tr>
<td>U.S. Strategic Material Supply Chain Assessment: Select Rare Earth Elements</td>
<td>2016</td>
</tr>
<tr>
<td>U.S. Strategic Material Supply Chain Assessment: Titanium</td>
<td>Spring 2016</td>
</tr>
<tr>
<td>U.S. Strategic Material Supply Chain Assessment: Carbon Fiber Composites</td>
<td>Fall 2015</td>
</tr>
<tr>
<td>Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages (Update)</td>
<td>Feb. 2015</td>
</tr>
<tr>
<td>National Security Assessment of the Cartridge and Propellant Actuated Device Industry: 4th Review</td>
<td>July 2013</td>
</tr>
<tr>
<td>National Aeronautics and Space Administration (NASA) Industrial Base – Post-Space Shuttle</td>
<td>June 2012</td>
</tr>
<tr>
<td>Defense Industrial Base Assessment of the Telecommunications Industry Infrastructure</td>
<td>Apr. 2012</td>
</tr>
<tr>
<td>Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages</td>
<td>Aug. 2010</td>
</tr>
<tr>
<td>Critical Technology Assessment: Impact of U.S. Export Controls on Green Technology Items</td>
<td>Aug. 2010</td>
</tr>
<tr>
<td>Technology Assessment of Fine Grain, High-Density Graphite</td>
<td>Apr. 2010</td>
</tr>
<tr>
<td>Defense Industrial Base Assessment of Counterfeit Electronics</td>
<td>Jan. 2010</td>
</tr>
<tr>
<td>Technology Assessment of 5-Axis Machine Tools</td>
<td>July 2009</td>
</tr>
</tbody>
</table>

For further information about OTE’s programs or for copies of assessments please visit [http://www.bis.doc.gov/dib](http://www.bis.doc.gov/dib). Please visit [www.bis.doc.gov/232](http://www.bis.doc.gov/232) for Section 232 Investigations and [www.bis.doc.gov/criticaltech](http://www.bis.doc.gov/criticaltech) for Technology Assessments.
### Archived Assessments

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defense Industrial Base Assessment of the U.S. Space Industry</td>
<td>Aug. 2007</td>
</tr>
<tr>
<td>Technology Assessment of Certain Aromatic Polyimides</td>
<td>July 2007</td>
</tr>
<tr>
<td>Economic Impact Assessment of the Air Force C-17 Program</td>
<td>Dec. 2005</td>
</tr>
<tr>
<td>National Security Assessment of the Munitions Power Sources Industry</td>
<td>Dec. 2005</td>
</tr>
<tr>
<td>National Security Assessment of the Air Delivery (Parachute) Industry</td>
<td>May 2004</td>
</tr>
<tr>
<td>Industry Attitudes on Collaborating with DoD in R&amp;D – Air Force</td>
<td>Jan. 2004</td>
</tr>
<tr>
<td>Industrial Base Assessment of U.S. Textile and Apparel Industries</td>
<td>Sept. 2003</td>
</tr>
<tr>
<td>Heavy Manufacturing Industries: Economic Impact and Productivity of Welding – Navy</td>
<td>June 2002</td>
</tr>
<tr>
<td>The Effect of Imports of Iron Ore and Semi-Finished Steel on the National Security</td>
<td>Oct. 2001</td>
</tr>
<tr>
<td>National Security Assessment of the U.S. High-Performance Explosives &amp; Components Sector</td>
<td>June 2001</td>
</tr>
<tr>
<td>Statistical Handbook of the Ball and Roller Bearing Industry (Update)</td>
<td>June 2001</td>
</tr>
<tr>
<td>National Security Assessment of the U.S. Shipbuilding and Repair Industry</td>
<td>May 2001</td>
</tr>
<tr>
<td>The Effect on the National Security of Imports of Crude Oil and Refined Petroleum Products</td>
<td>Nov. 1999</td>
</tr>
<tr>
<td>U.S. Commercial Technology Transfers to The People’s Republic of China</td>
<td>Jan. 1999</td>
</tr>
<tr>
<td>Critical Technology Assessment of Optoelectronics</td>
<td>Oct. 1998</td>
</tr>
</tbody>
</table>