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

U.S. Bare Printed Circuit Board Industry Assessment:

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For more information about the Office of Technology Evaluation, Industrial Base Studies and Section 232 Investigations, please visit:
http://www.bis.doc.gov/dib and http://www.bis.doc.gov/232

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

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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

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

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

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

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.

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

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.

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

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.

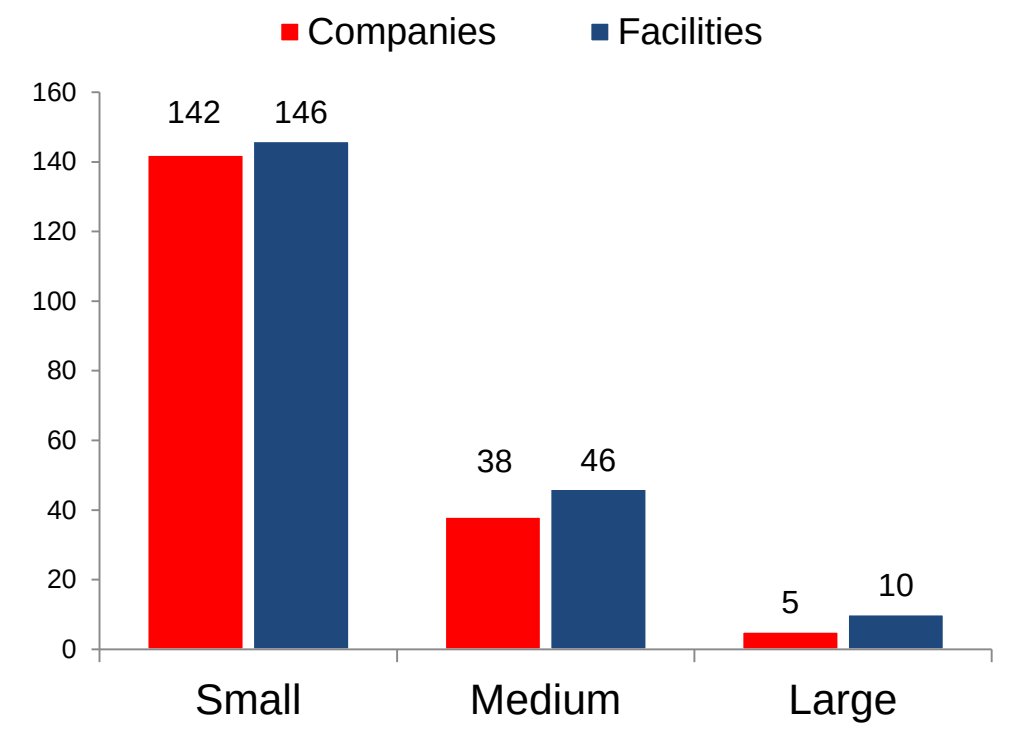
BIS Survey Design and Data Collection

- 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 PARTICIPATON

Survey Respondent Profile/Organization Information



- 185 companies operate 202 bare printed circuit board manufacturing facilities in the U.S. (2015)
  - 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

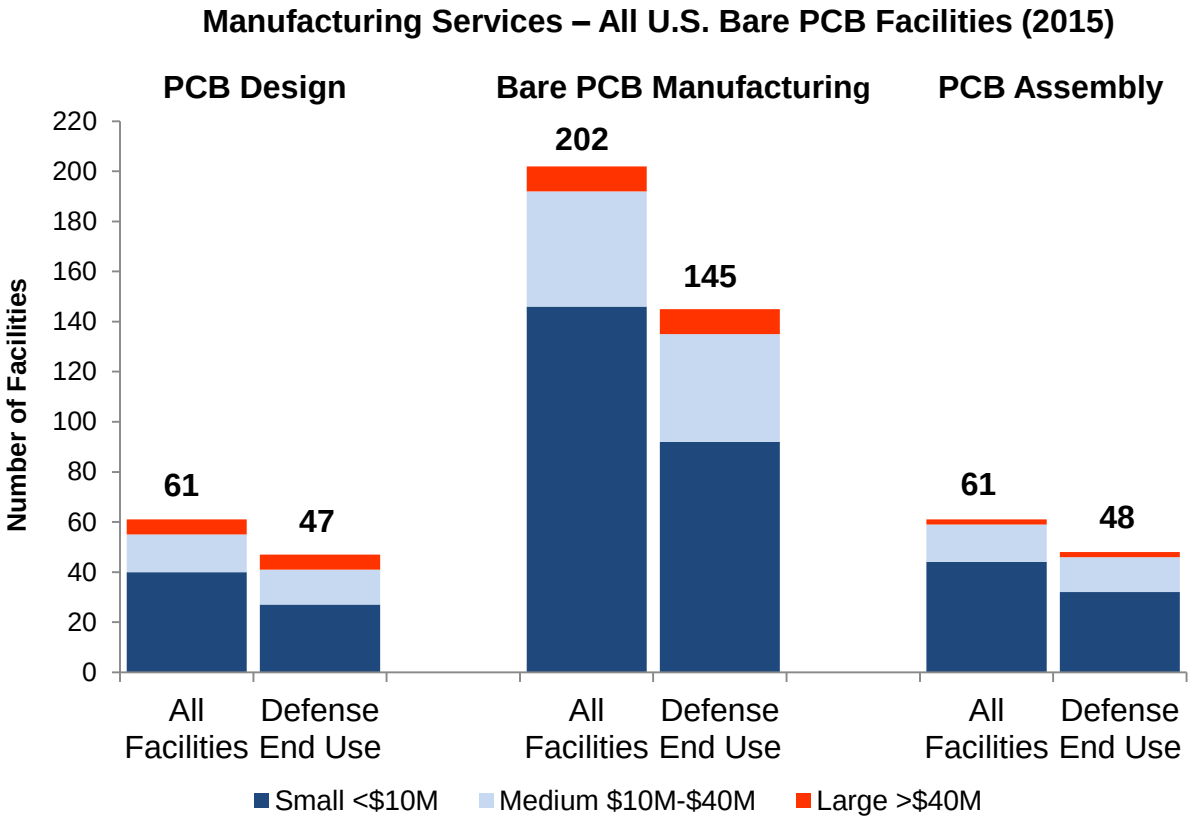
RP/Q7C

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 Capabilities

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.



Defense End Use

- 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.

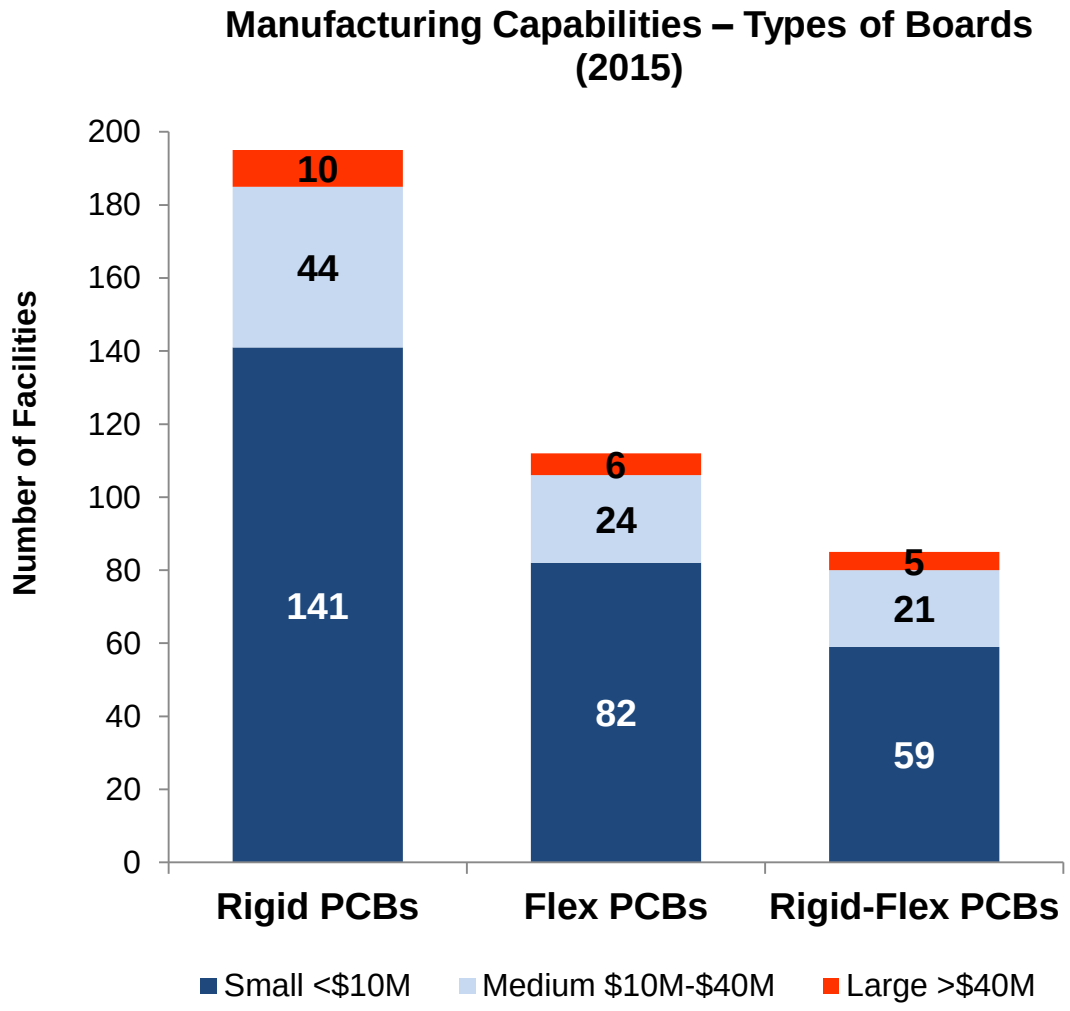
Q1c,A

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

Respondents: 202

Survey Respondent Profile/Organization Information

Facility Size and Bare PCB Manufacturing Capabilities



- 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

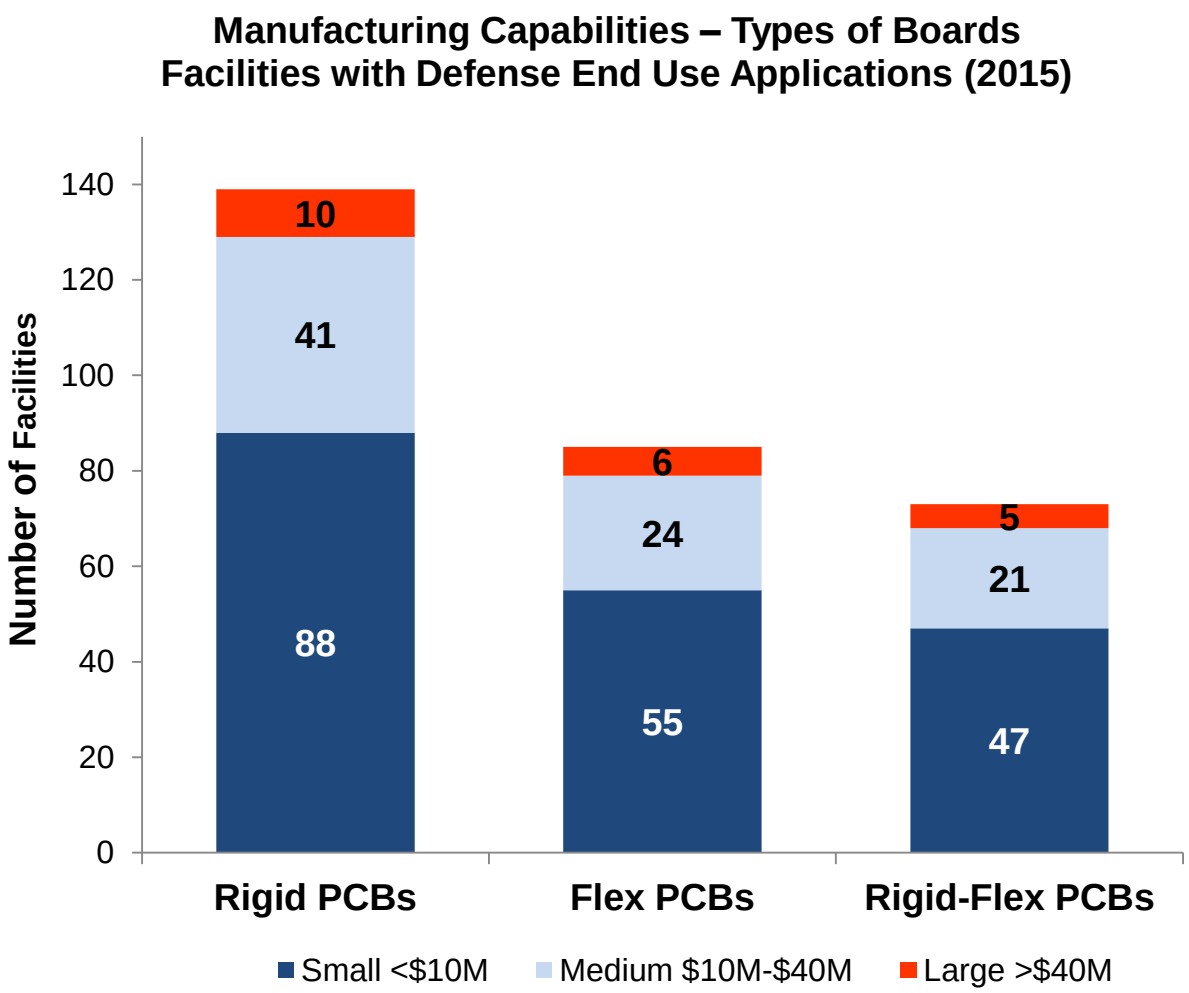
Q5a,A

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



145 Facilities with Defense End Use Production

- 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

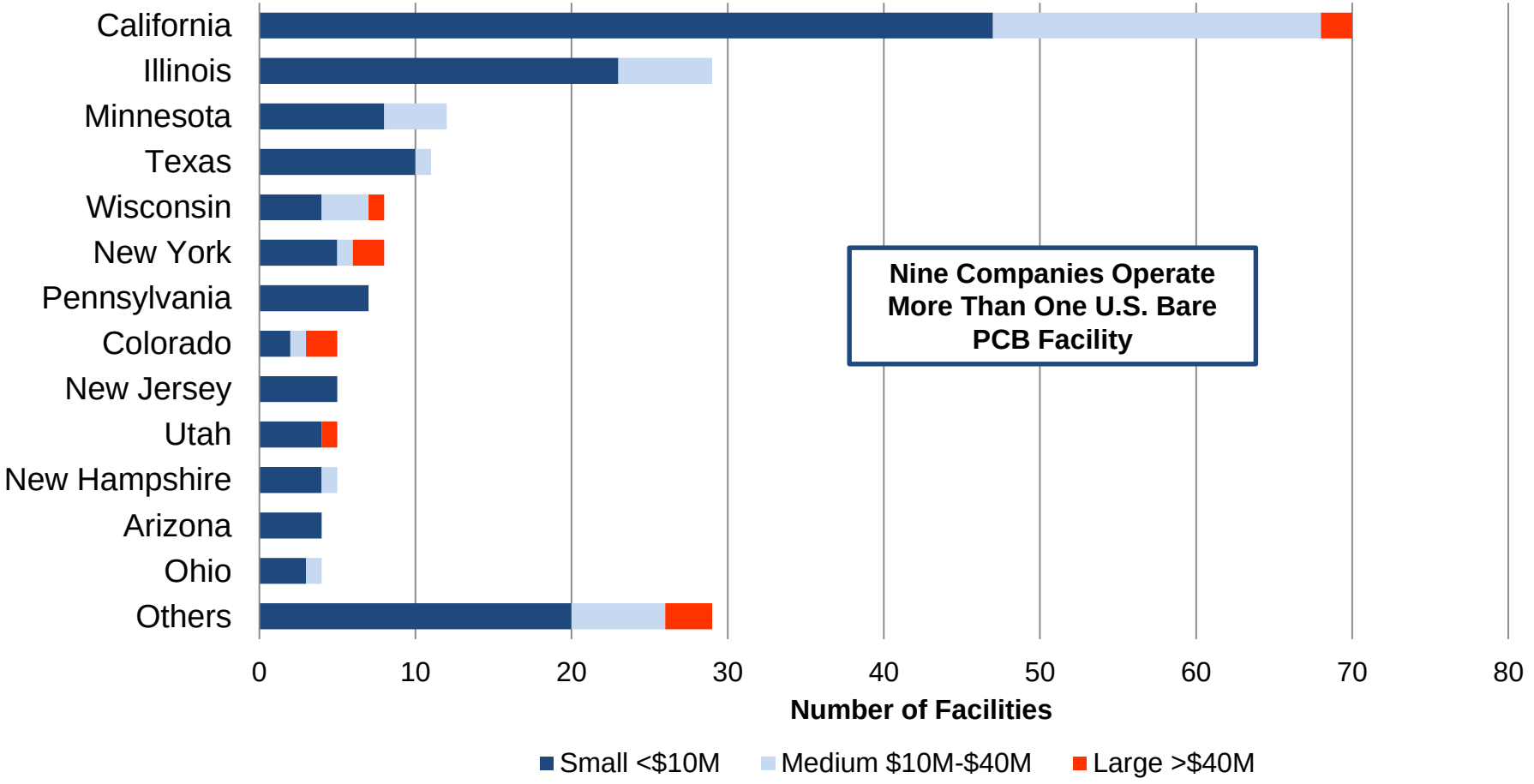
Q 1c,A / Q5aA

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

145 respondents

Survey Respondent Profile/Organization Information

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



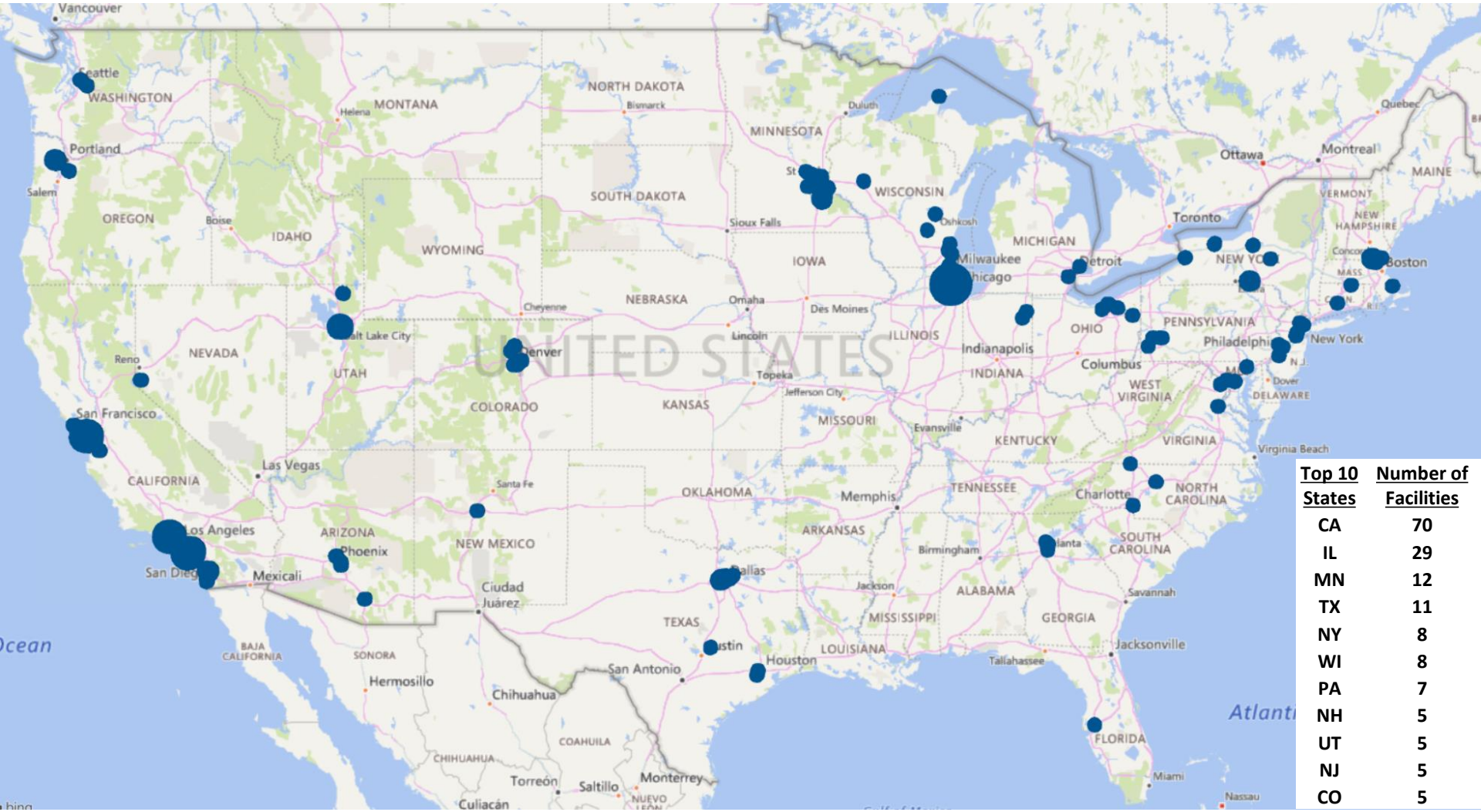
Q1a,A

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

202 respondents

Survey Respondent Profile/Organization Information

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



Top 10 States	Number of Facilities
CA	70
IL	29
MN	12
TX	11
NY	8
WI	8
PA	7
NH	5
UT	5
NJ	5
CO	5

Q1a,A

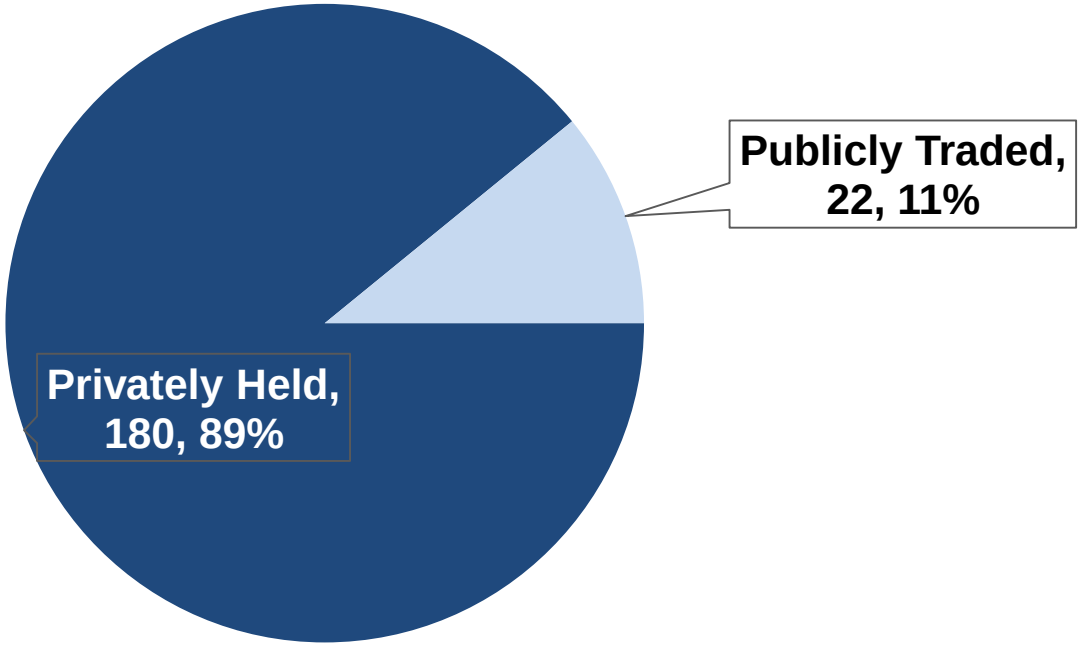
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017

202 respondents

Survey Respondent Profile/Organization Information

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)



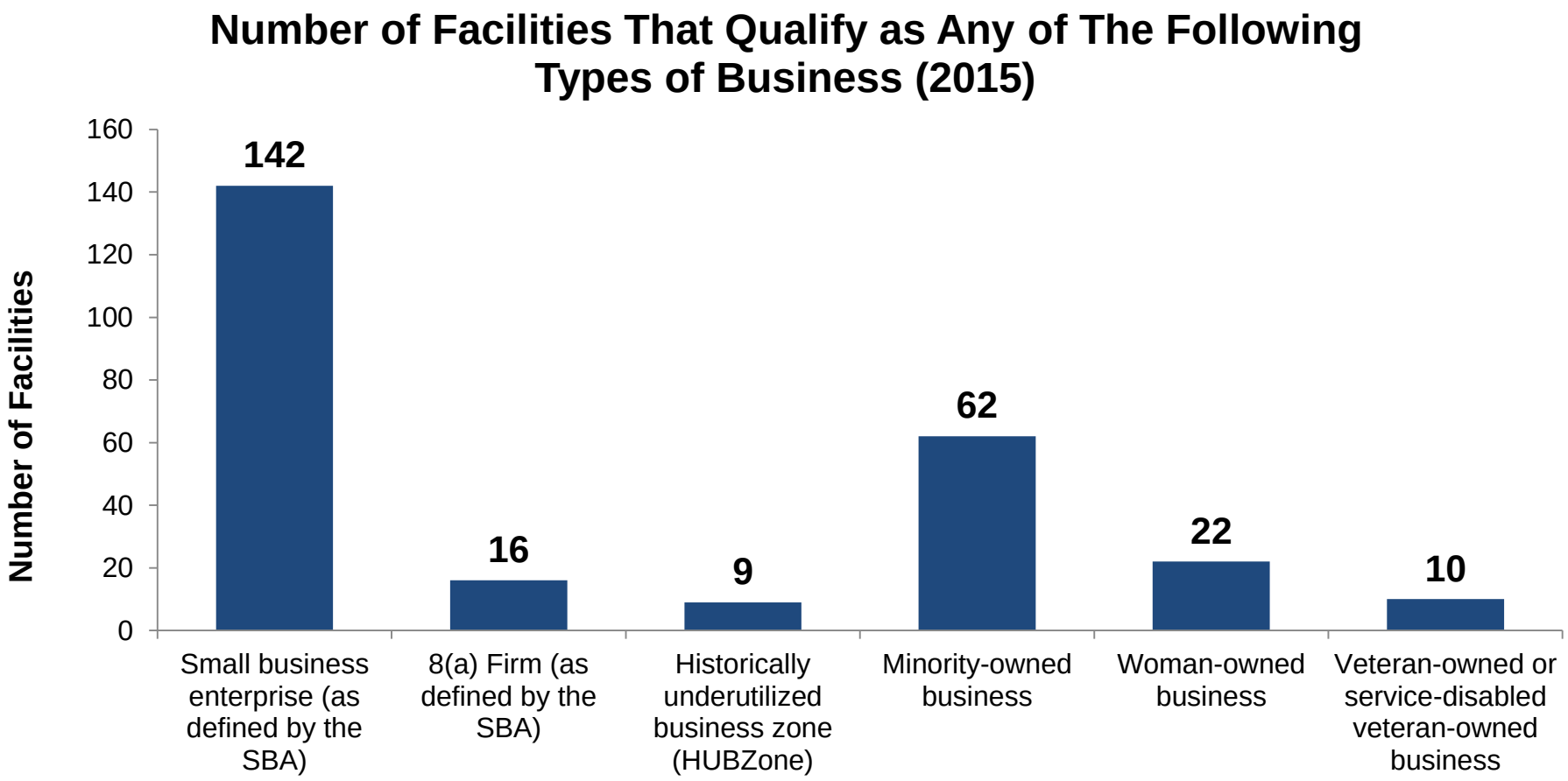
Q1a,C

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

U.S. Bare PCB Facilities: Types of Business Ownership



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

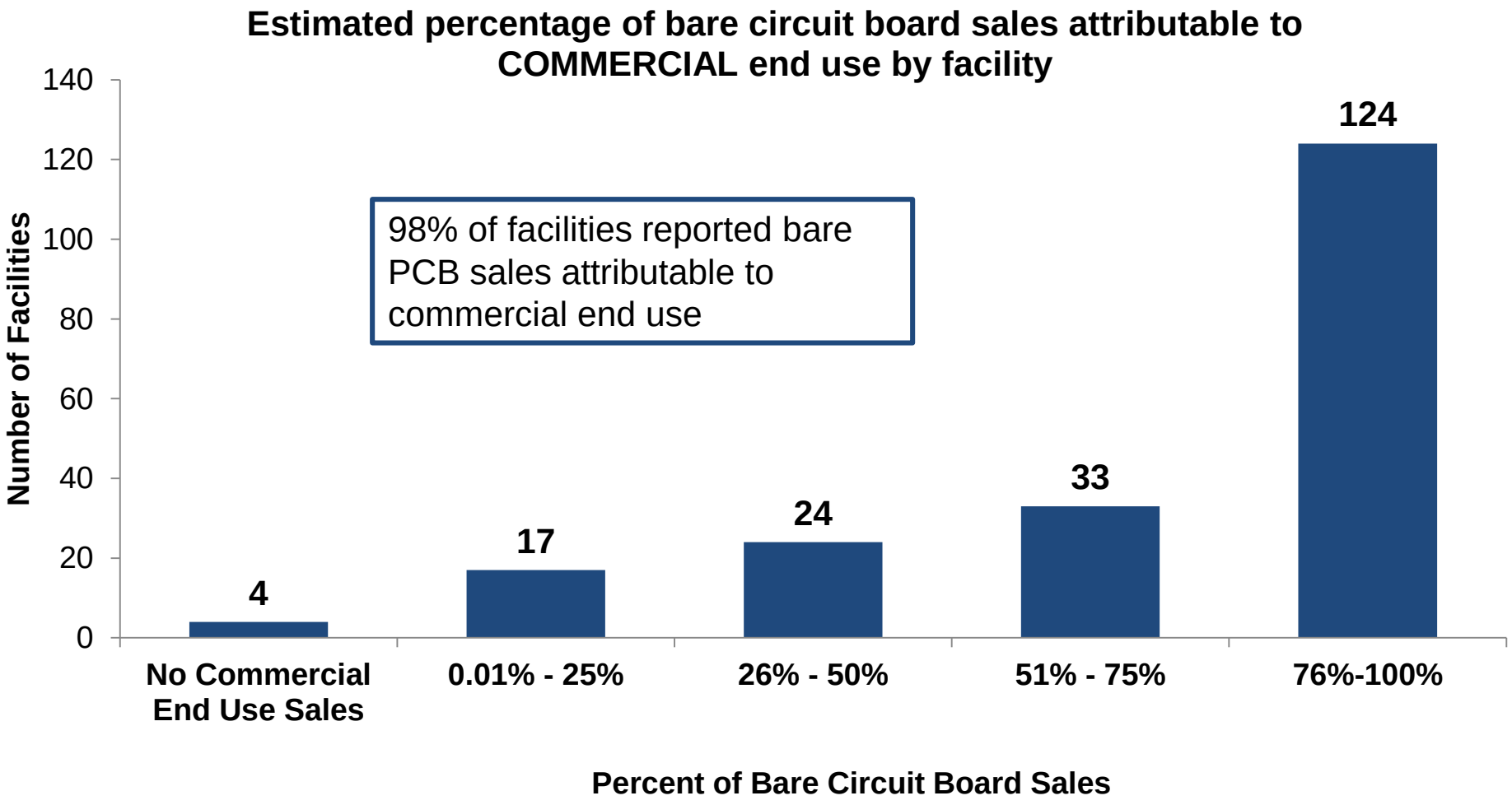
Q1b,C

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

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



Q1c,A

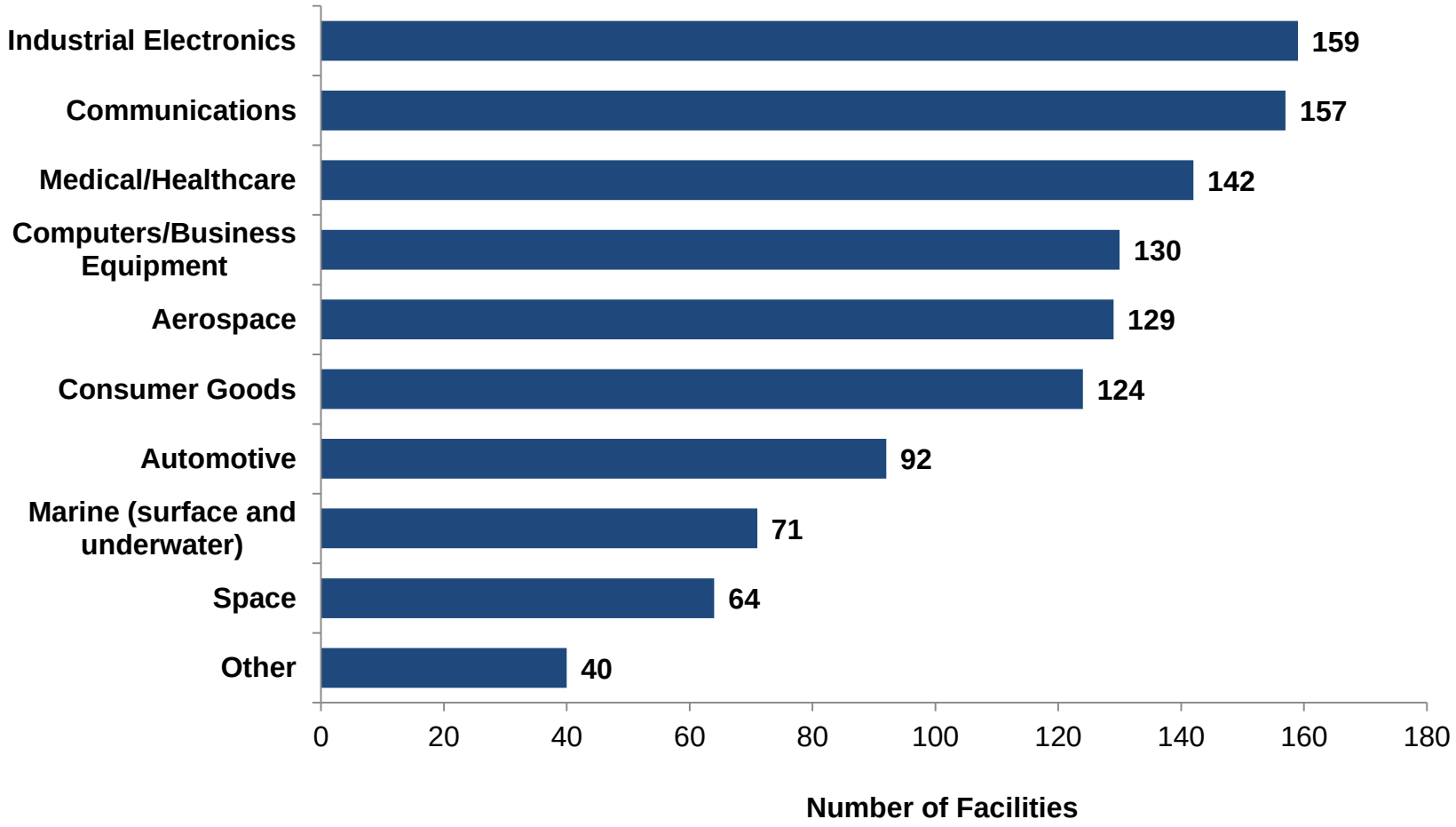
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment - 2017

202 respondents

Survey Respondent Profile/Organization Information

Commercial End Use Market Segments (2015)

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



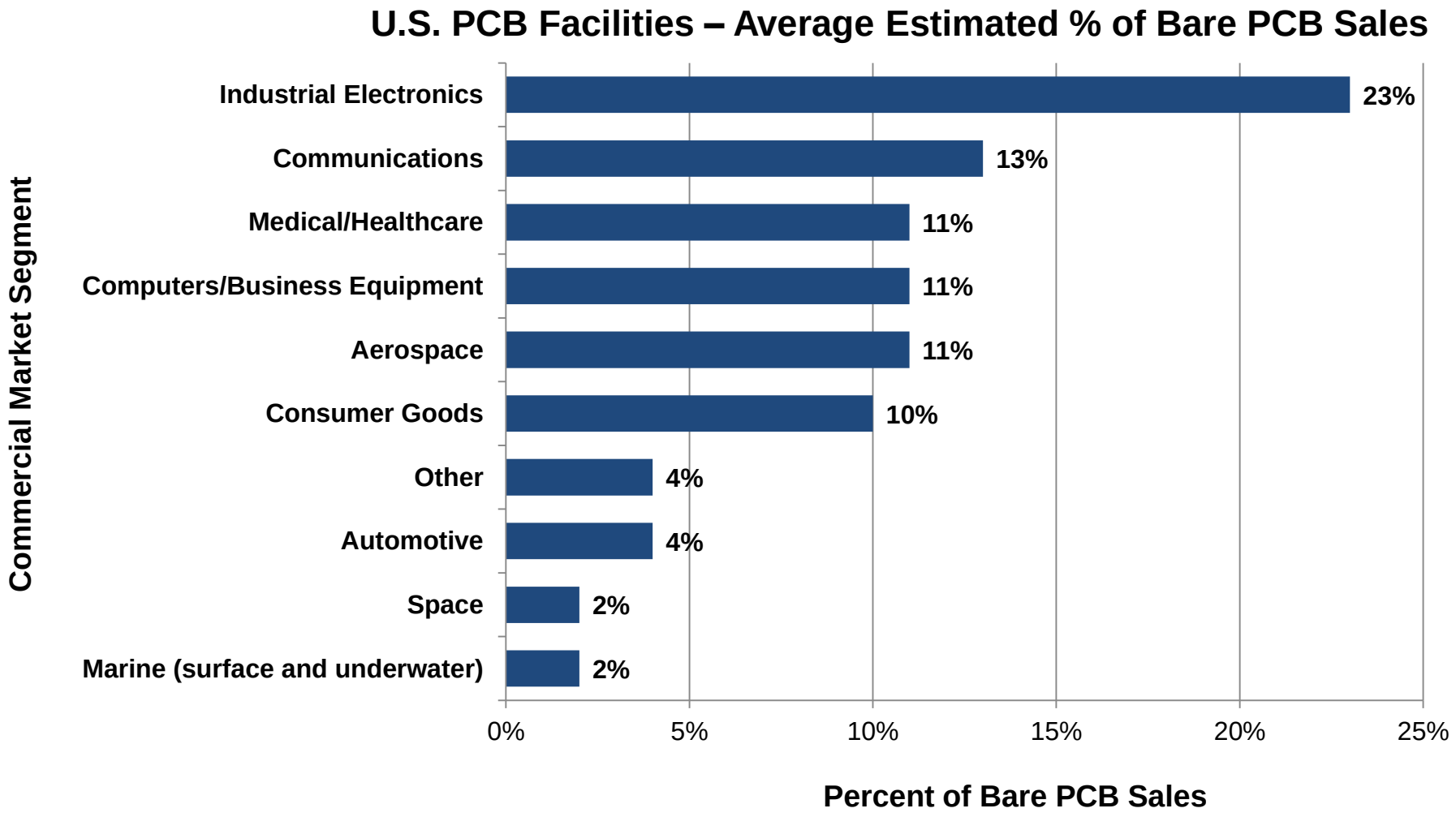
Q1c,A

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 Sales Percentages for Specific Commercial Uses



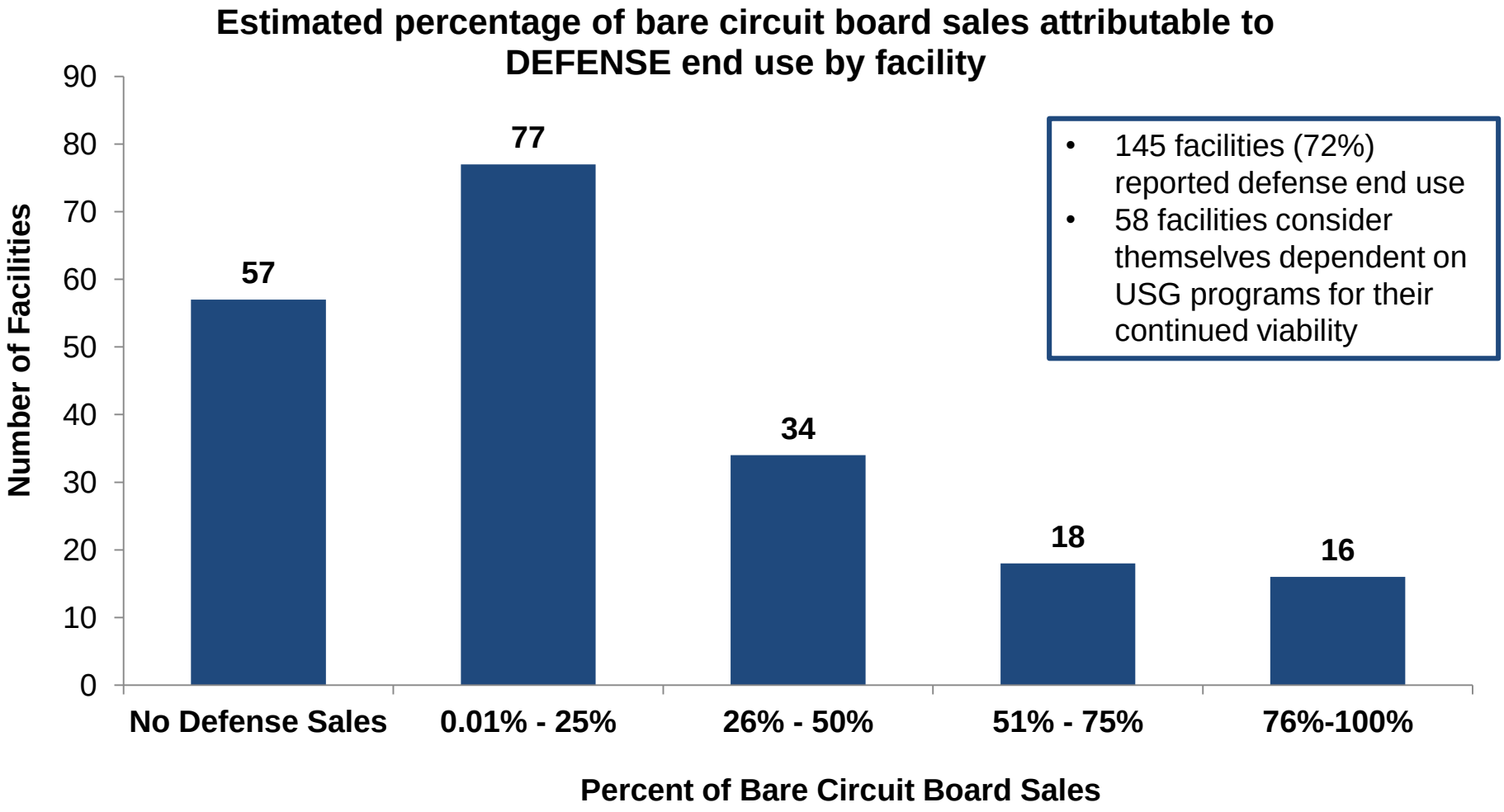
Q1c,B

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

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



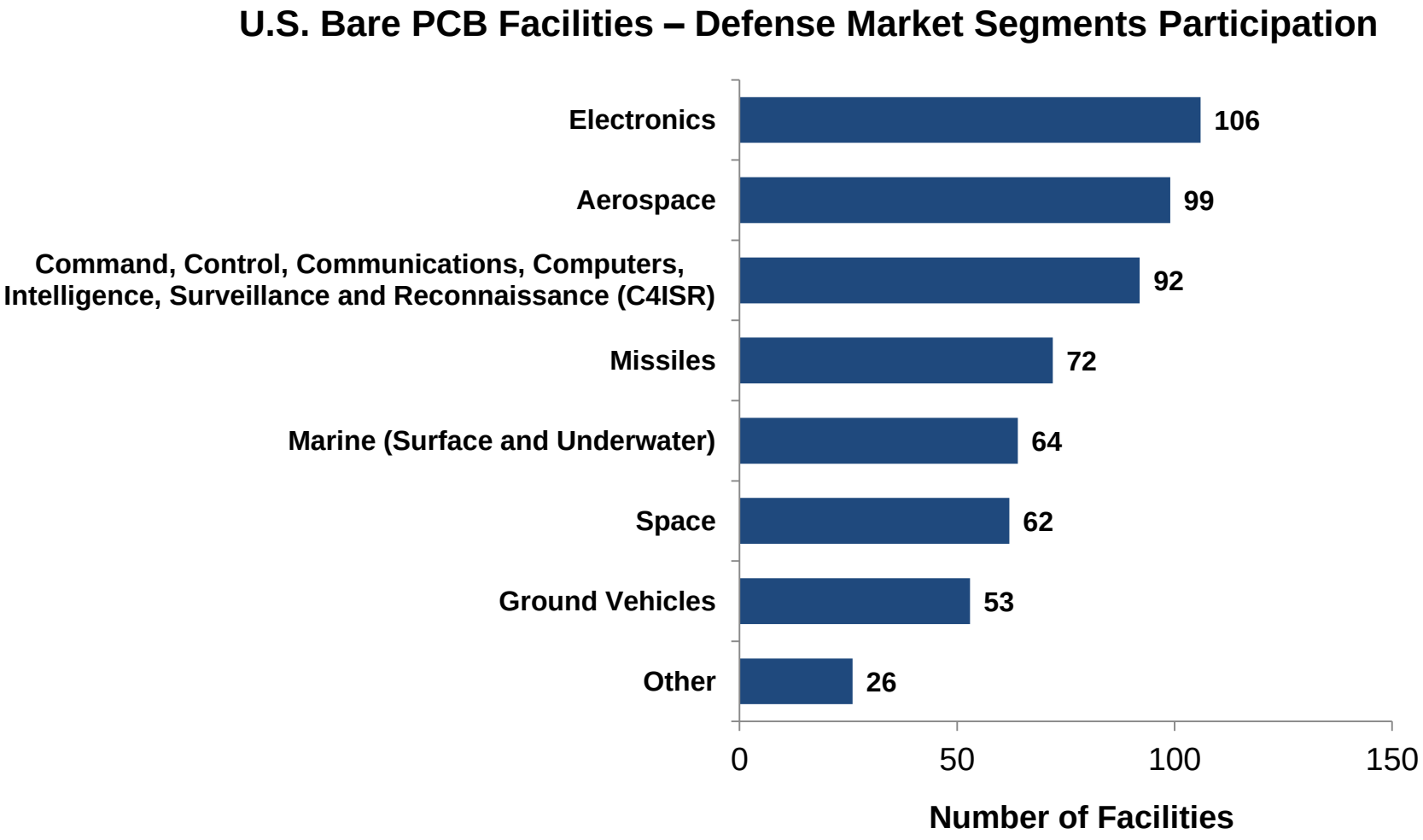
Q1c,A

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

202 respondents

Respondent Profile/Organization Information

Defense End Use Market Segments (2015)



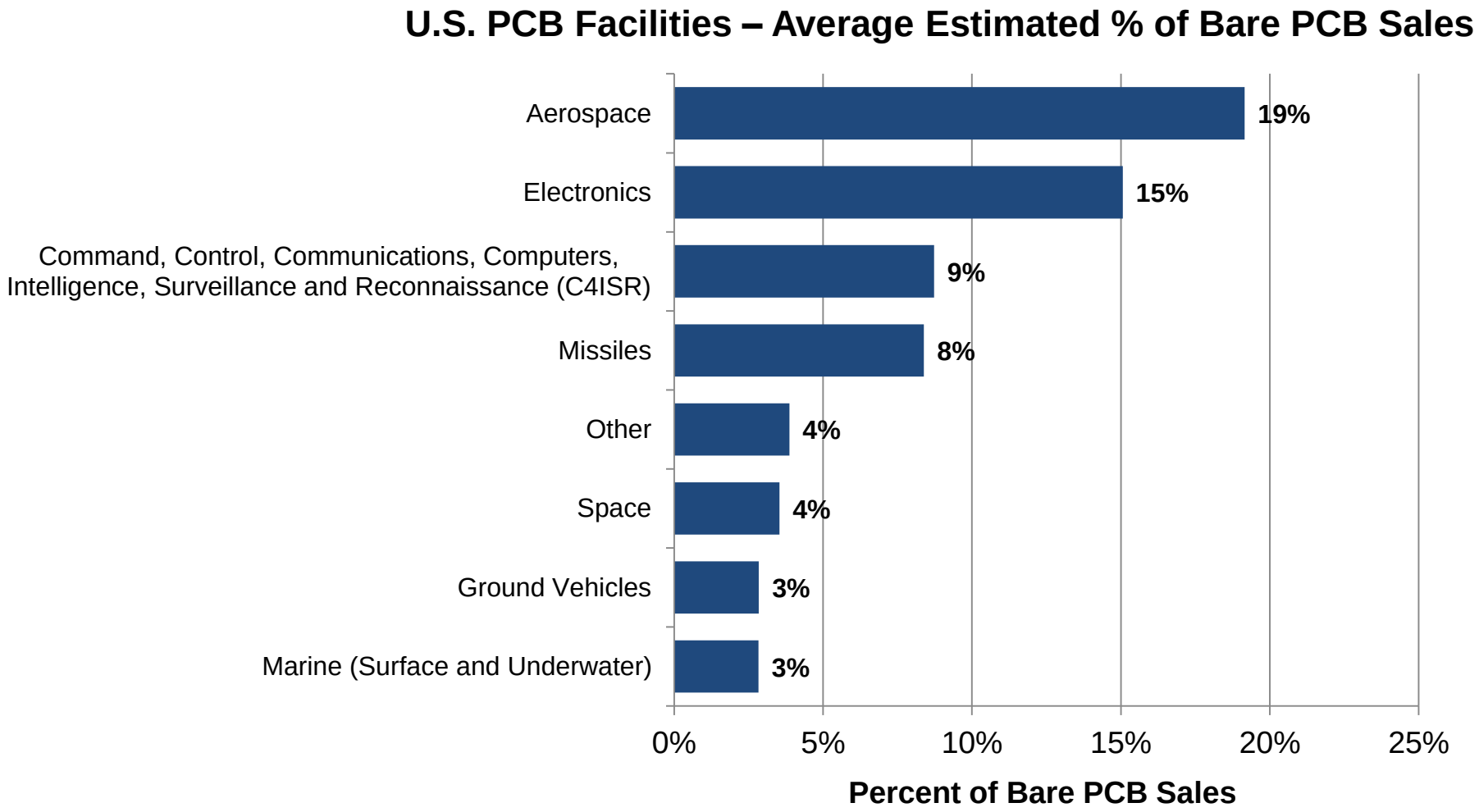
Q1c,A

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

145 respondents

Respondent Profile/Organization Information

Bare PCB Sales Percentages for Specific Defense Uses (2015)



Q1c,B

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

145 respondents

Survey Respondent Profile/Organization Information

Defense End Use Market Segments – Comments (2015)

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."

Q1c

202 respondents

Mergers and Acquisitions / Joint Ventures

Mergers and Acquisitions (M&As)

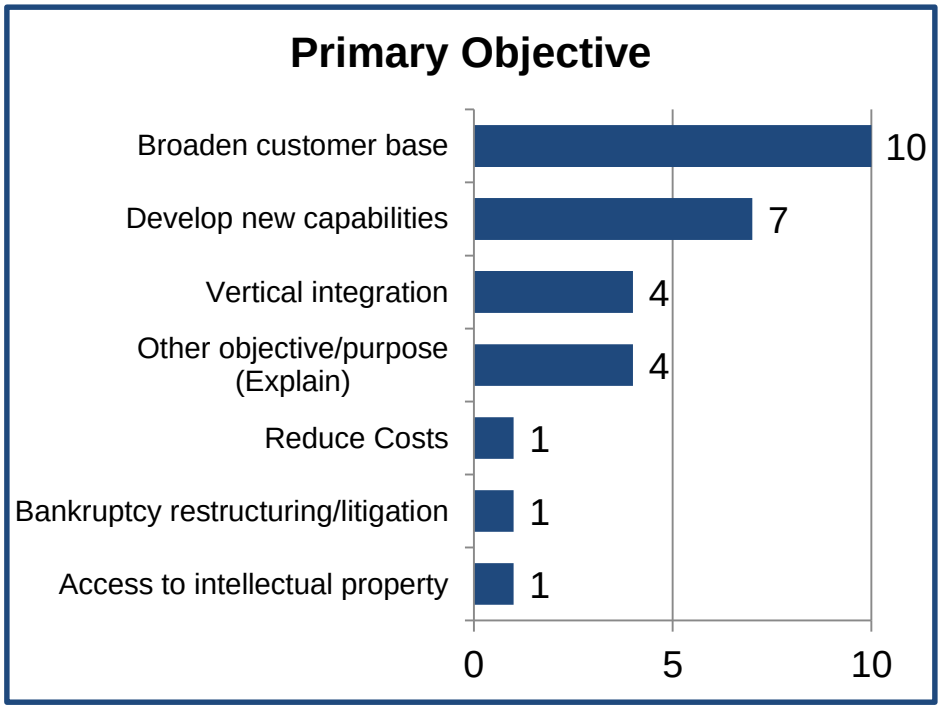
28 reported mergers and acquisitions since 2012

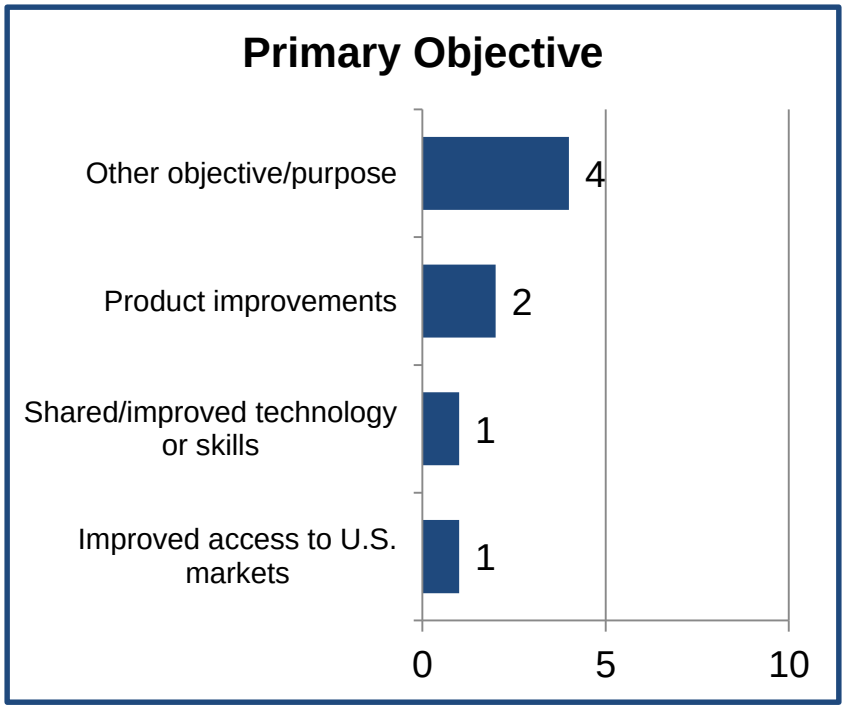
- 25 with U.S. companies
- 2 with Chinese companies
- 1 with a U.K. company

Joint Ventures (JVs)

8 joint ventures reported

- No data on country of JV entities
- "Other" JV objectives included co-production and broker partnership





Q2,A/B

202 respondents

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.

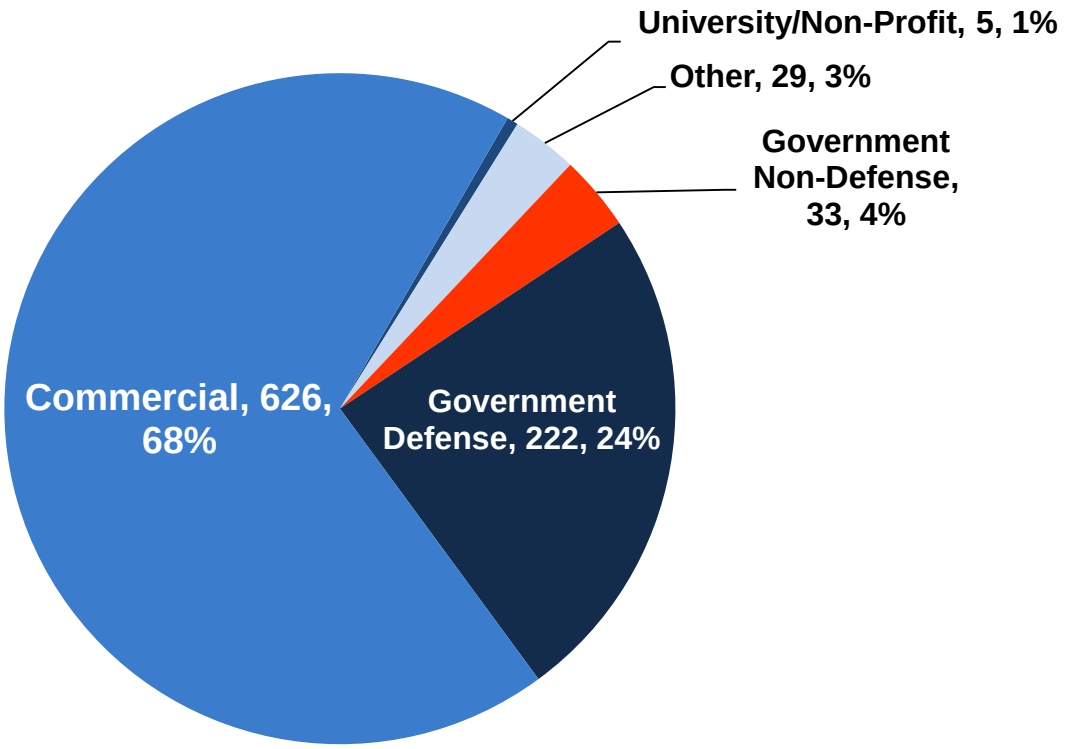
- 915 U.S customers were identified
  - Over two-thirds (68 percent) were commercial customers, with almost one-quarter (24 percent) Government Defense customers.
  - 'Electronics' was the leading primary end use with 29 percent of responses.
  - California was the number one state for top U.S. bare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

Customers & Competitors

U.S.-Based Bare Printed Circuit Board Customers (2012-2015)

Types of U.S. Customers (915 total)



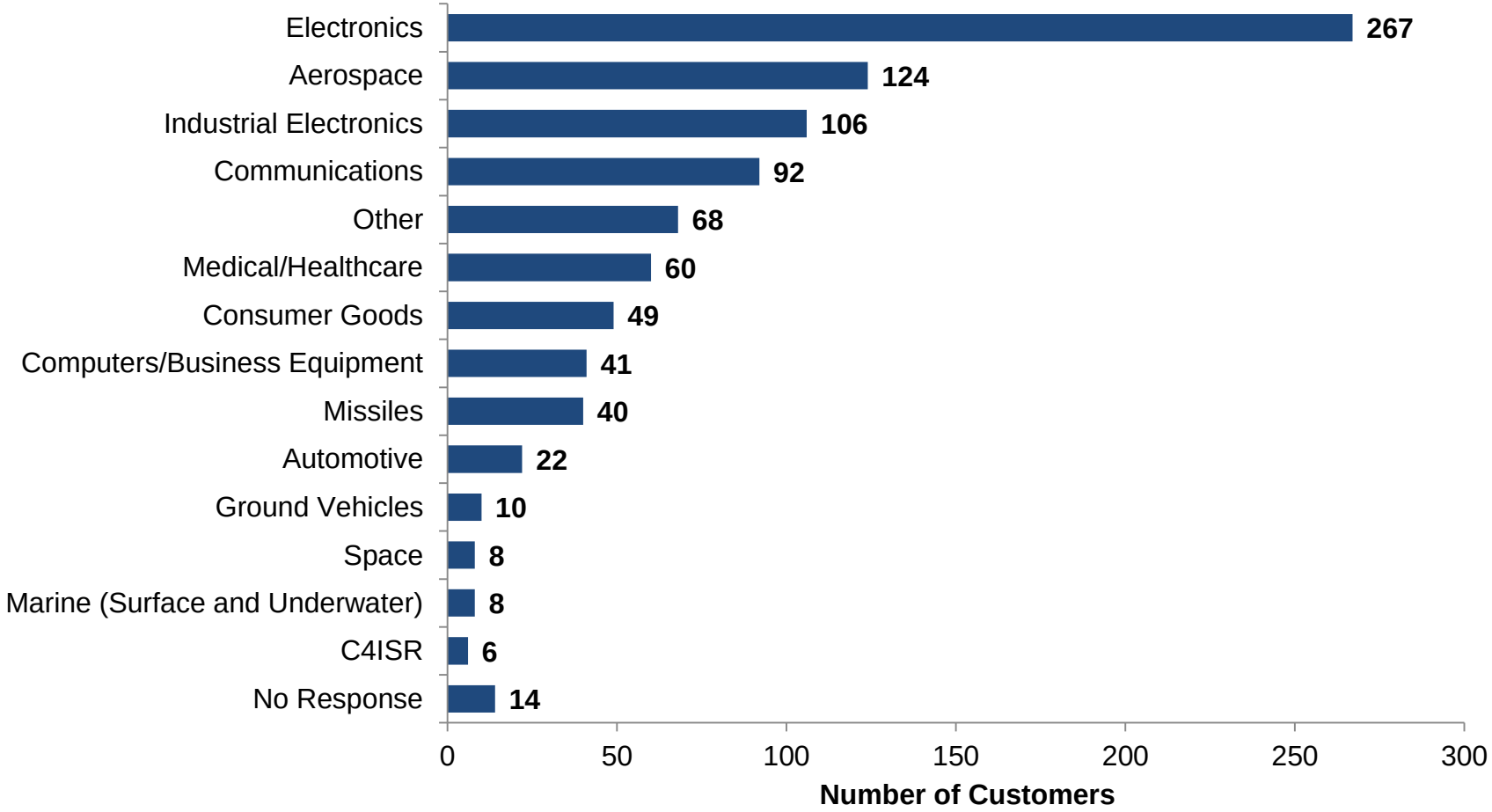
Q3a,C

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 Primary End Use (2012-2015)

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



Q3a,C

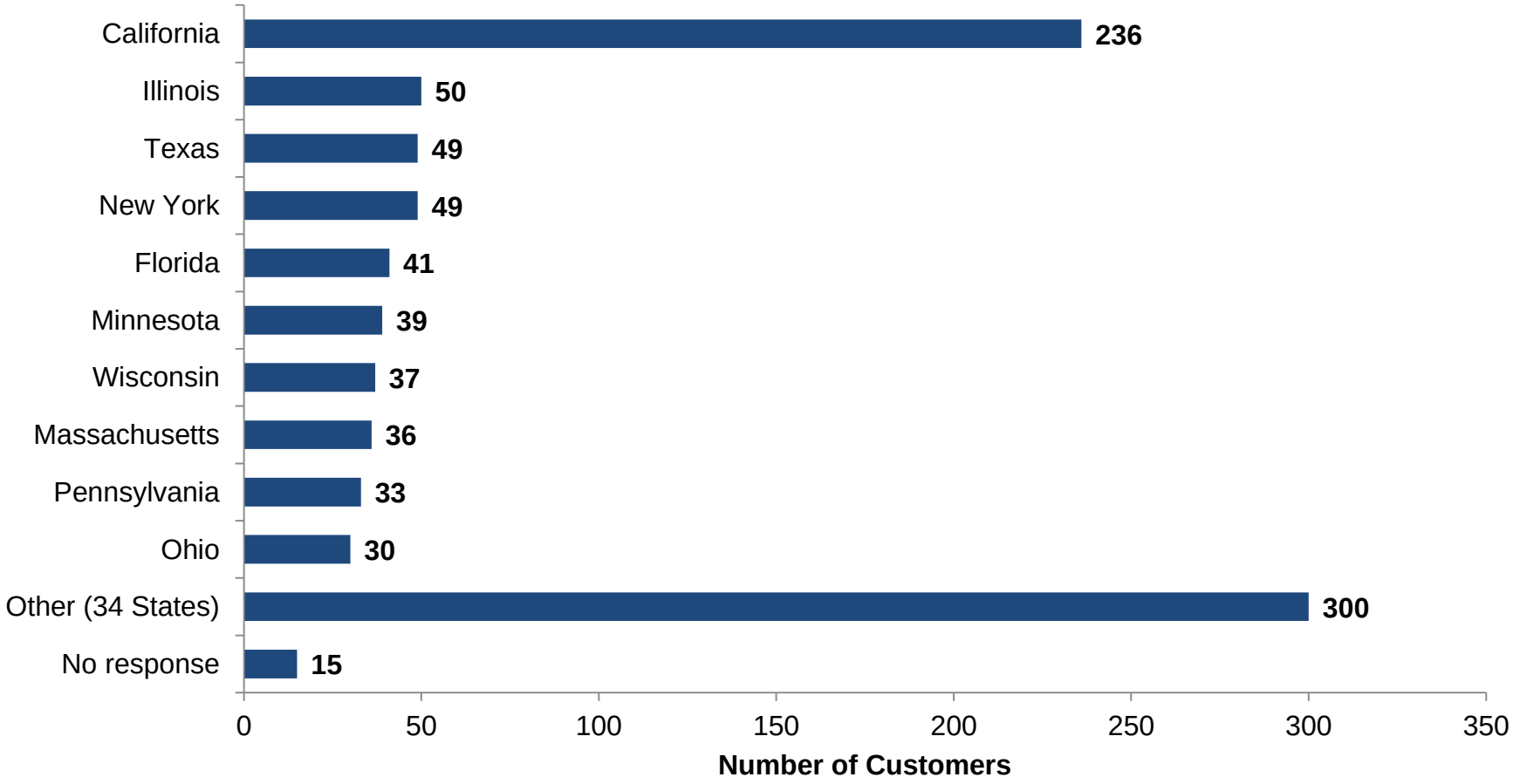
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Customers & Competitors

U.S.-Based Customers By State (2012-2015)

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



Q3a,C

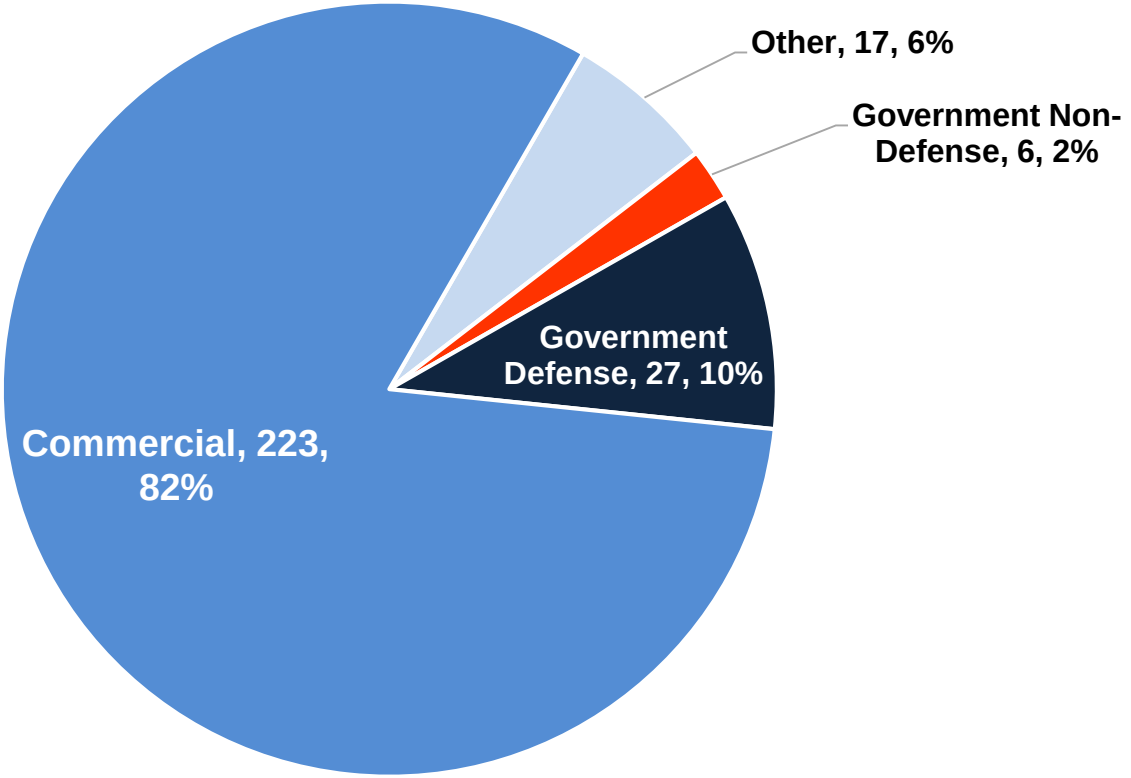
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Customers & Competitors

Non-U.S.-Based Bare Printed Circuit Board Customers (2012-2015)

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



Q3a,C

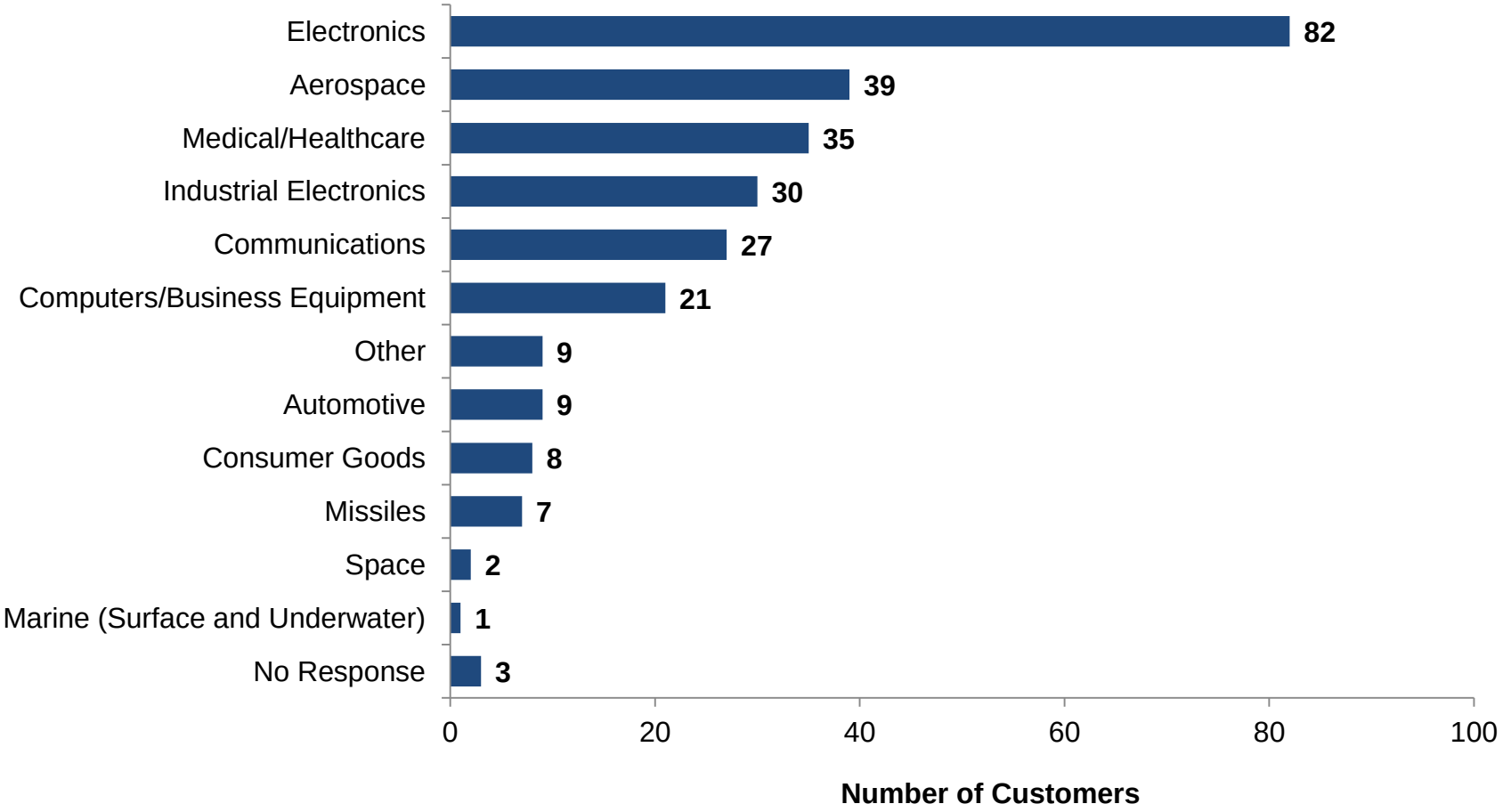
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

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



Q3a,C

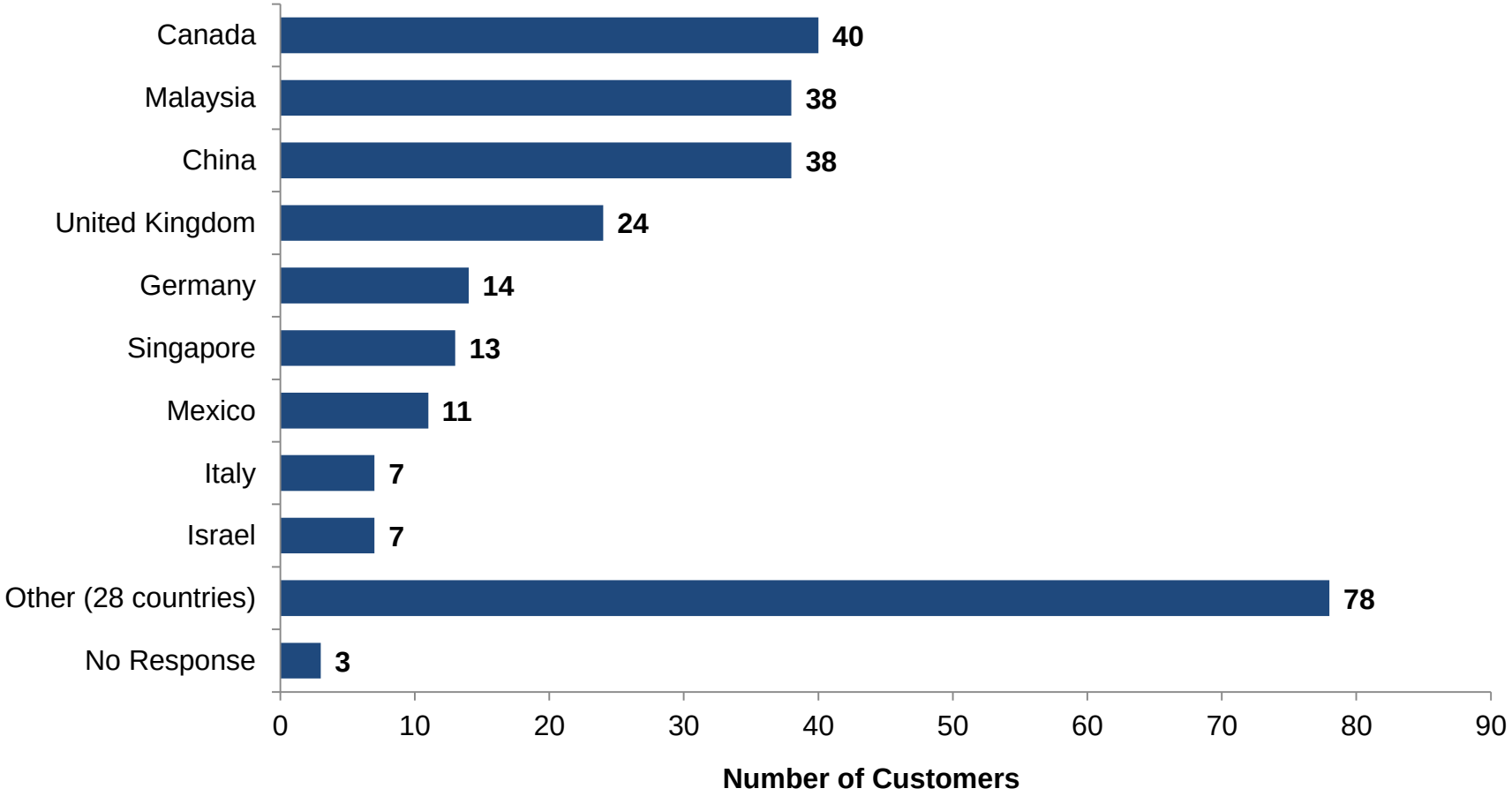
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Customers & Competitors

Non-U.S. Based Customers By Country (2012-2015)

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



Q3a,C

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

202 respondents

Customers & Competitors

Rejected Business Opportunities (2012-2015)

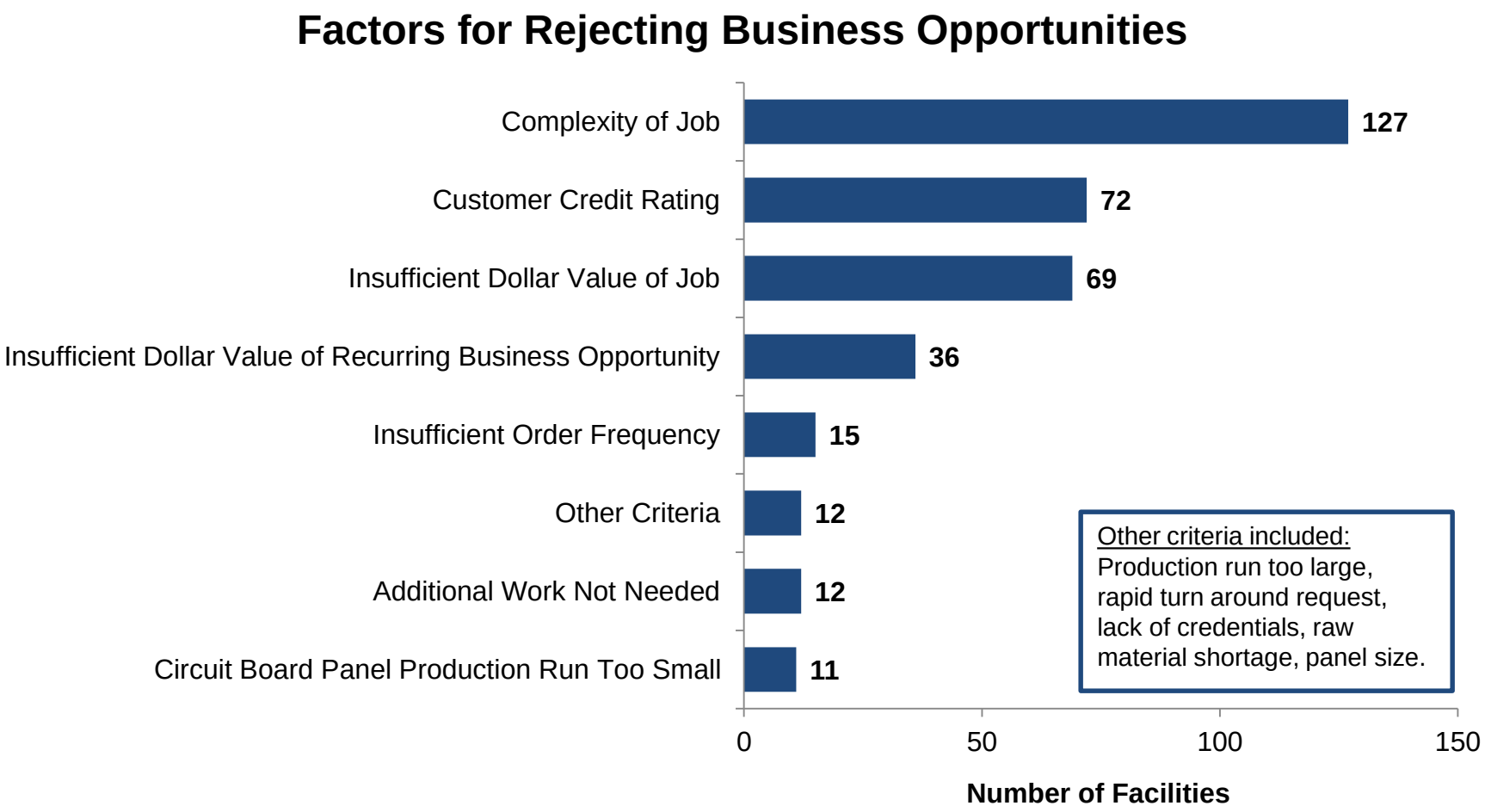
Respondents were asked whether they has rejected any business opportunities due to any of a number of factors. The leading factor for rejecting business opportunities in the responses was 'Complexity of Job.' Comments received included:

- "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.

Customers & Competitors

Rejected Customer Business Opportunities (2012-2015)



Q3a,B

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

Factor for Rejecting Business Opportunity	Explanation
Complexity of Job	"Design at RFQ was beyond process capabilities." "Do not posses 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."

Q3a,B

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

202 respondents

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.

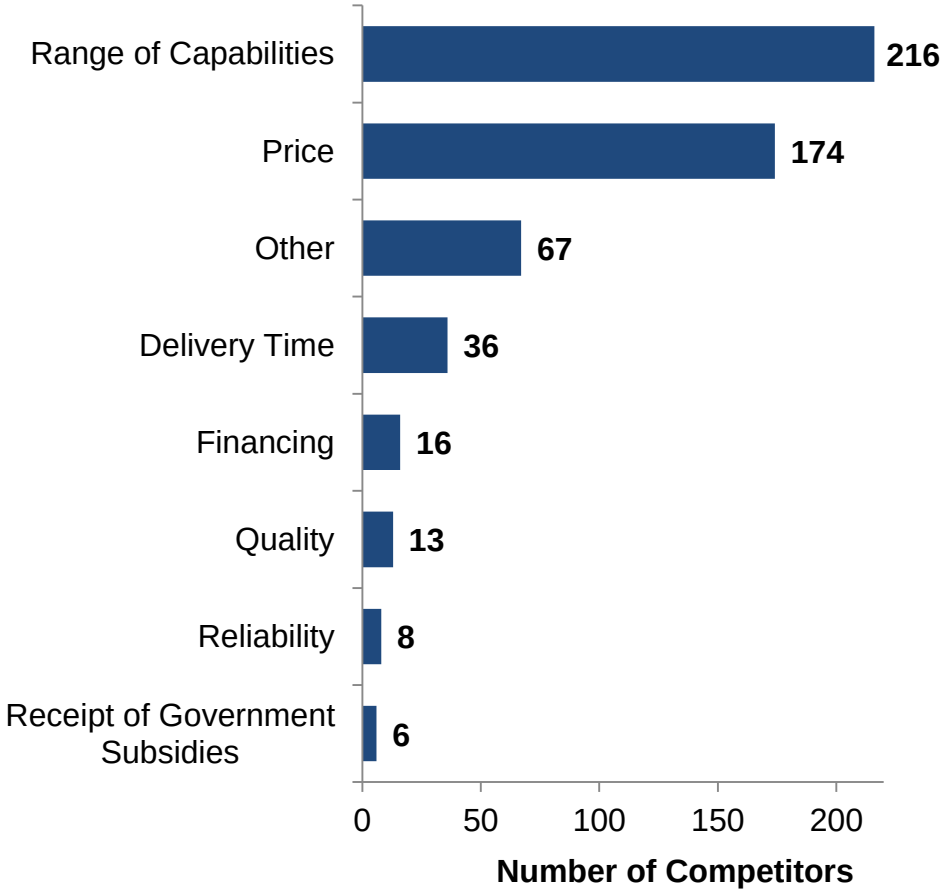
- 253 Non-U.S. competitors
  - ‘Price’ was the dominant primary competitive attribute identified, accounting for 76 percent of responses.
  - China was the leading location for non-U.S. competitors, accounting for 67 percent of responses.

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

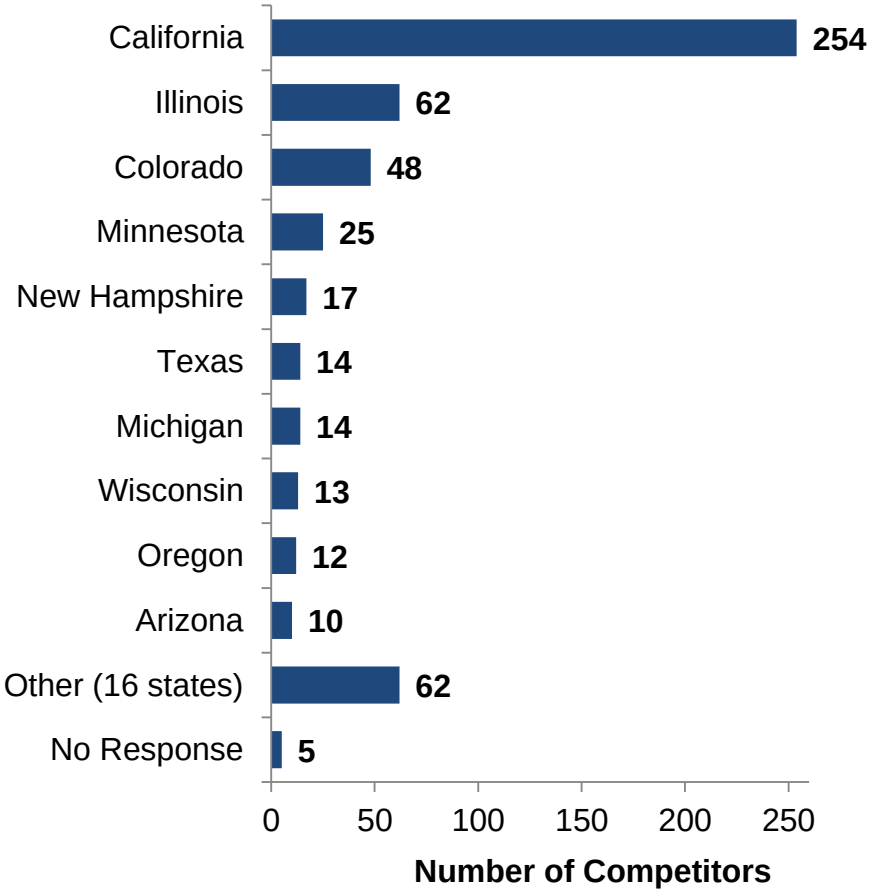
Customers & Competitors

Top U.S. Competitors: Key Factors and Geographic Location

U.S. Competitors – Primary Competitive Attribute



U.S. Competitors – Geographic Location



Q3b, B

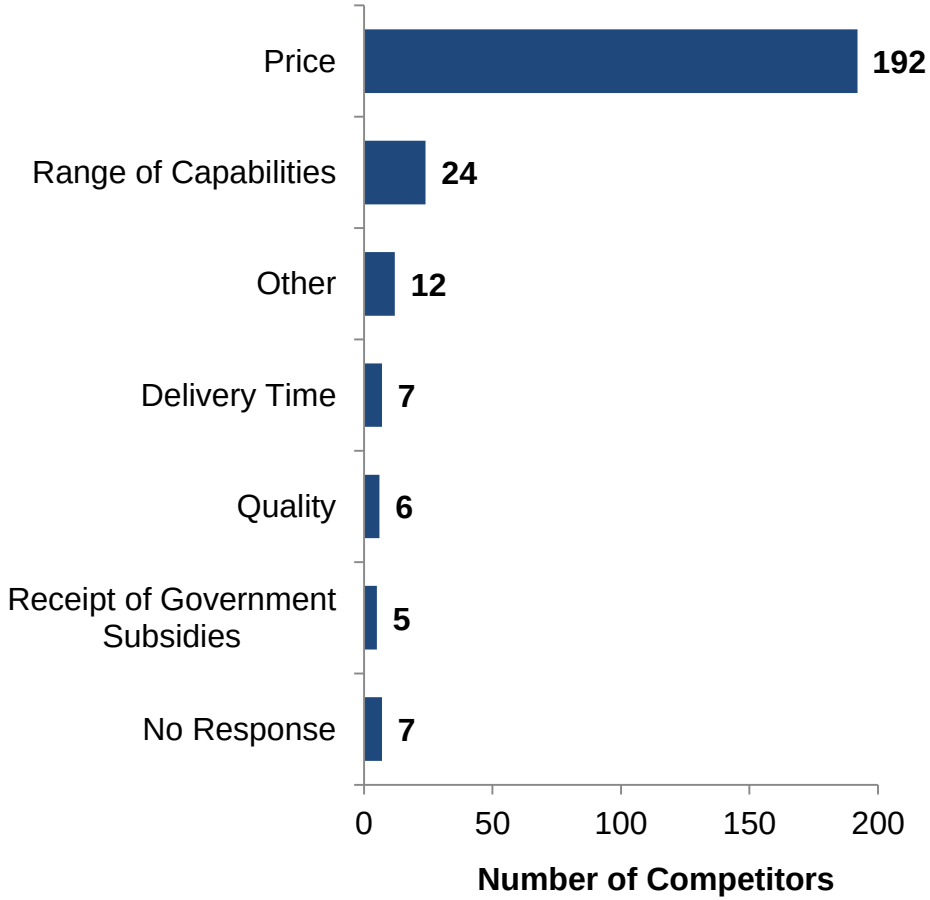
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

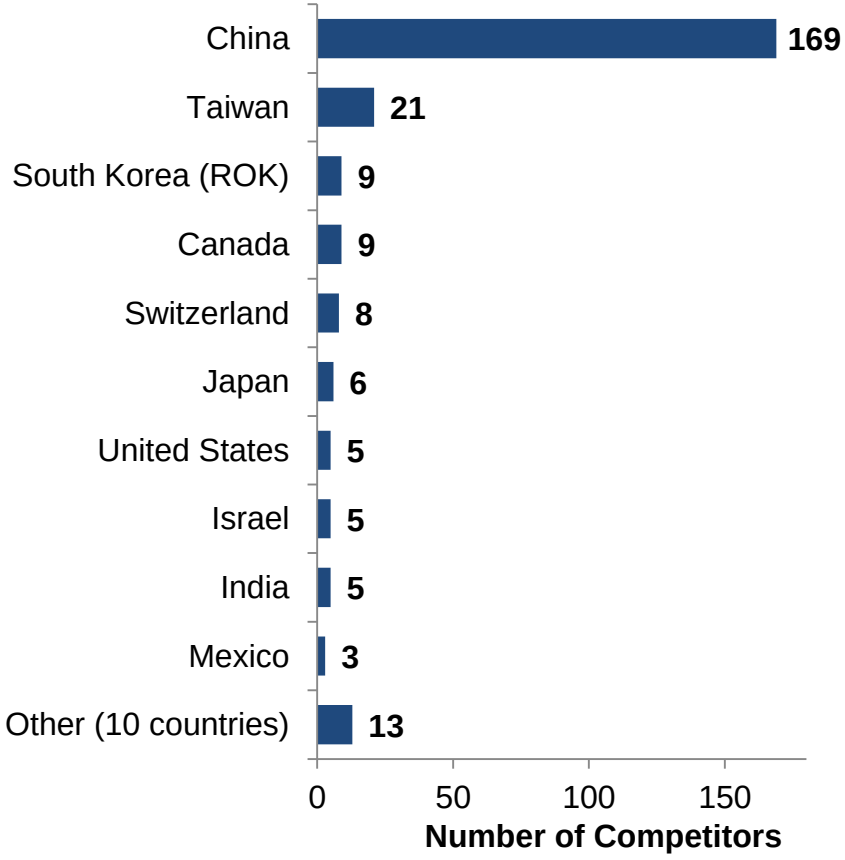
Customers & Competitors

Top Non-U.S. Competitors: Key Factors and Geographic Location

Non-U.S. Competitors – Primary Competitive Attribute



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



Q3b,B

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

202 respondents

Customers & Competitors

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

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

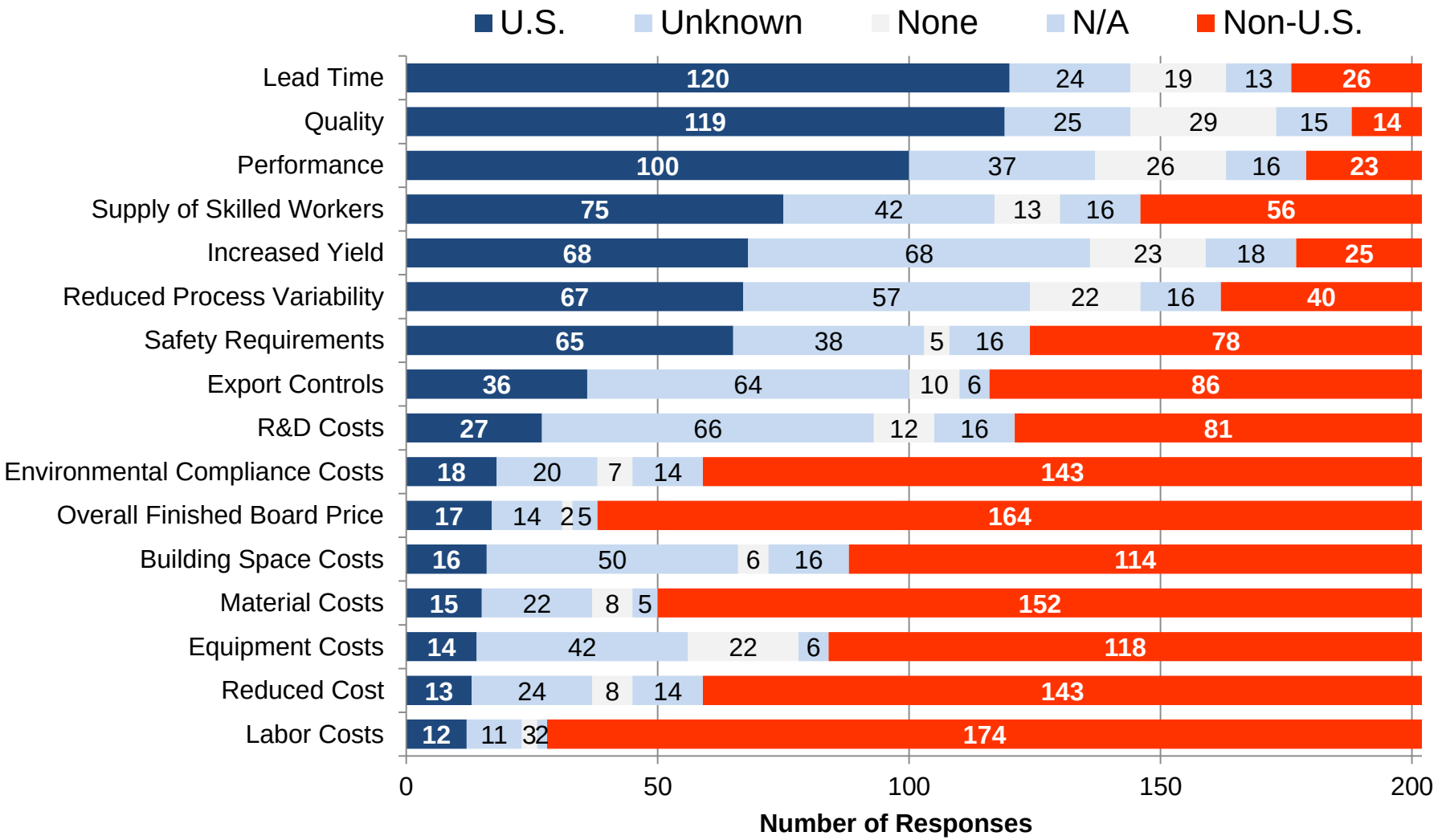
According to respondents, non-U.S. bare PCB manufacturers possess the comparative advantage in various costs which results in lower finished bare PCB prices:

- 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)



Q3b,A

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

202 Respondents

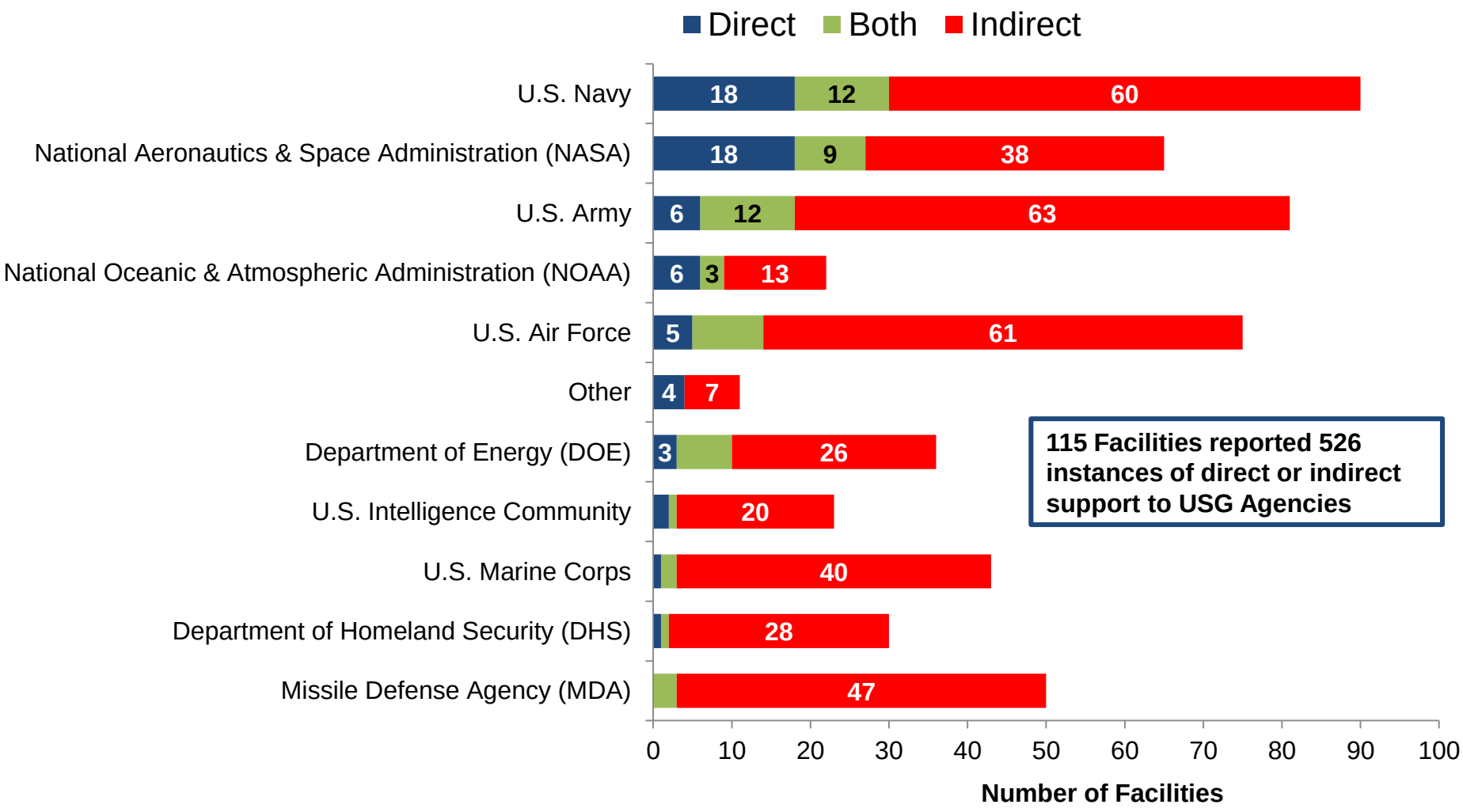
CHAPTER 3:

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

USG Programs - USG Agencies Supported (2012-2015)

Federal Agencies Supported by U.S. Bare Printed Circuit Board Facilities



Q4a,A

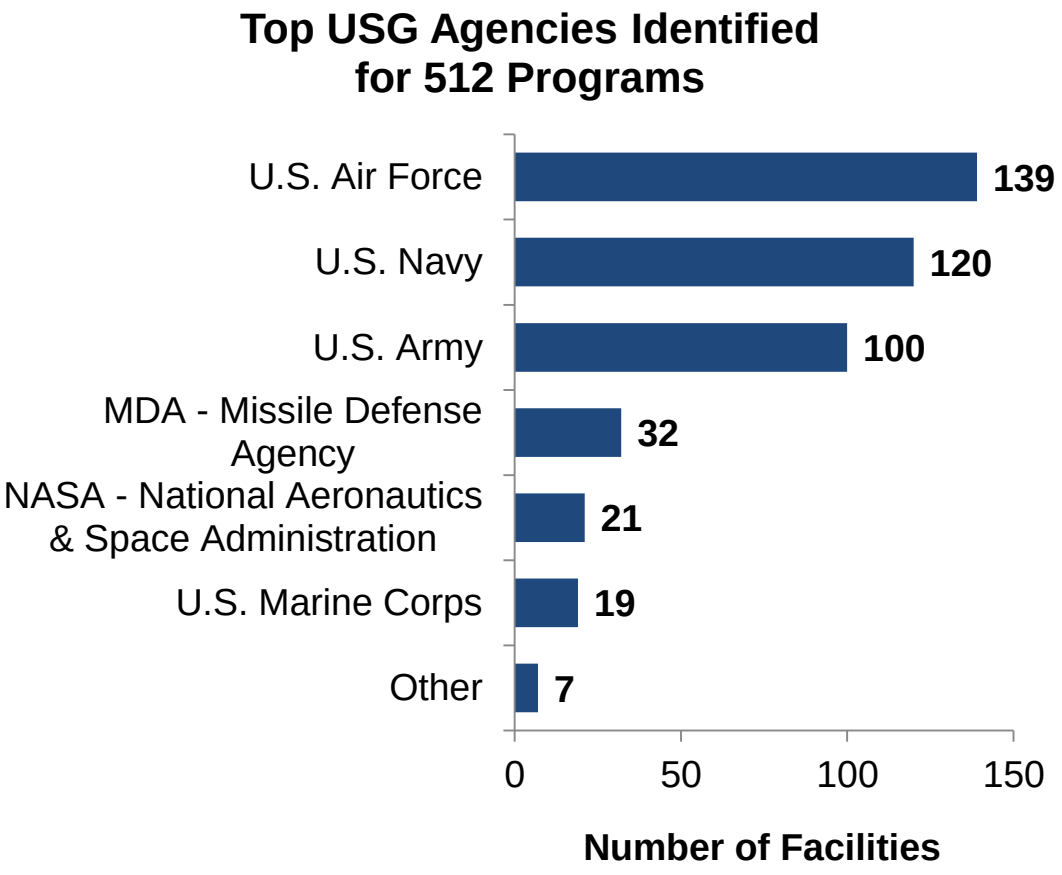
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

USG Programs

USG Agencies Relying on U.S. PCB Facilities (2012-2015)

- 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.



Q4a,B

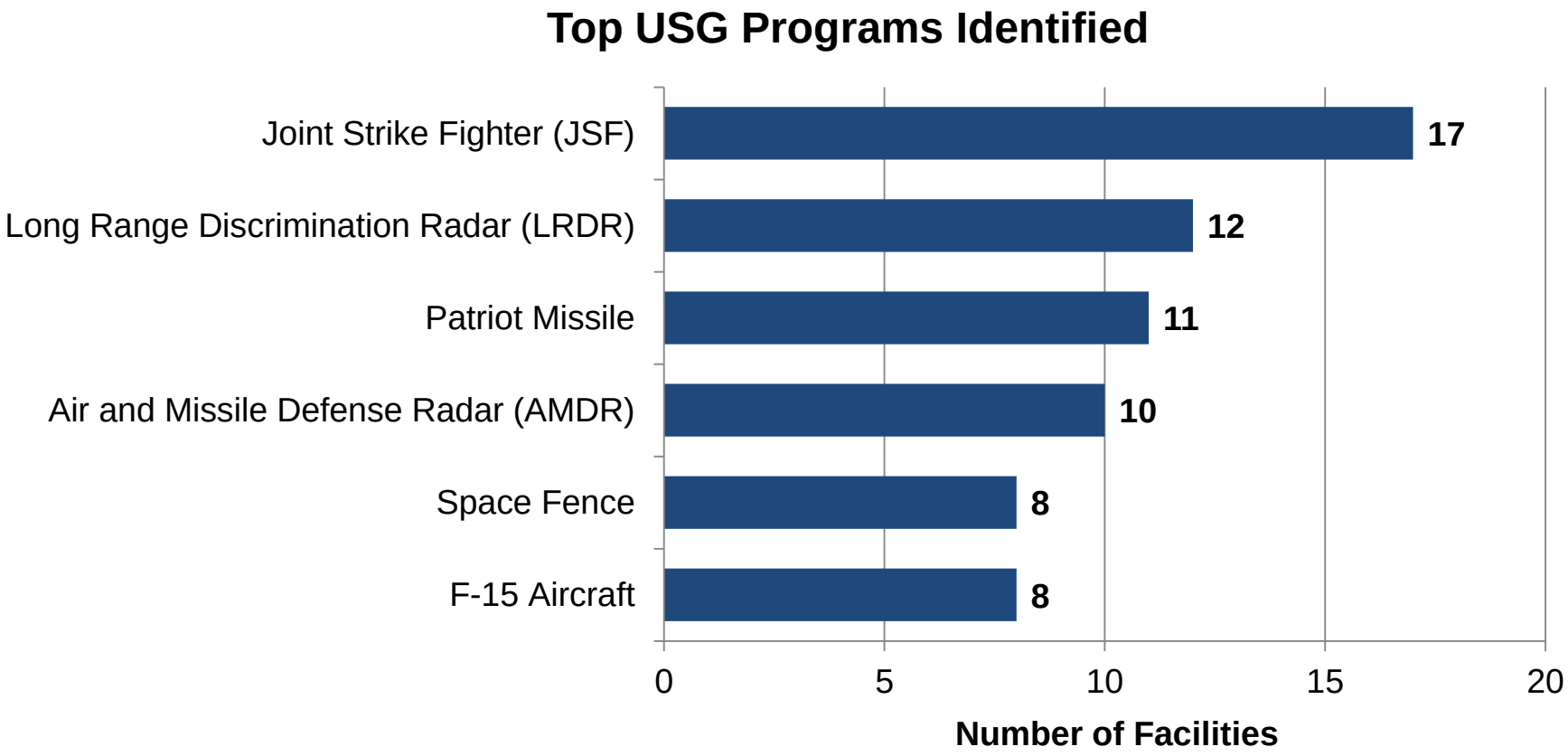
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

USG Programs

Government Systems Using U.S. Bare PCBs (2012-2015)

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



Q4a,B

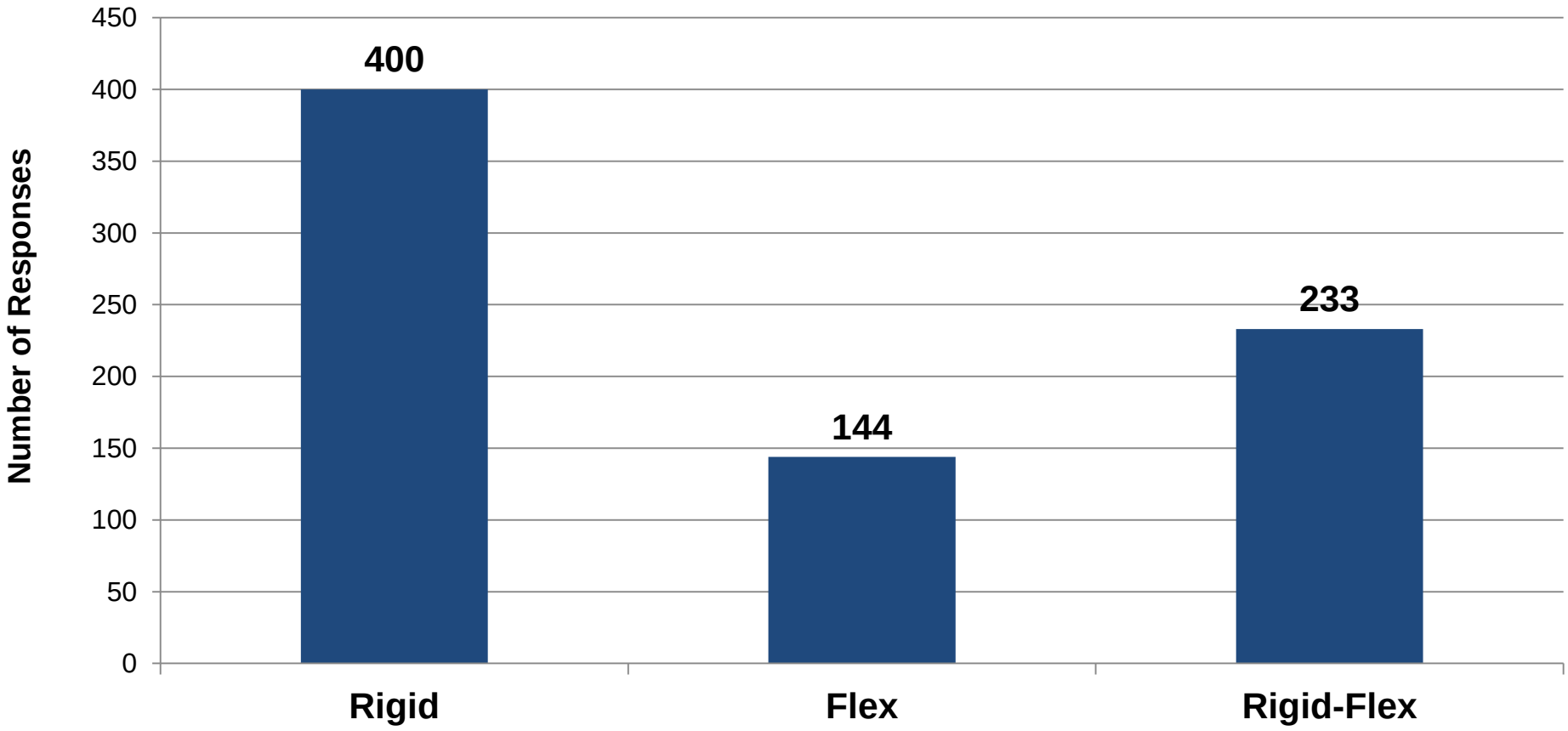
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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



Q4a,B

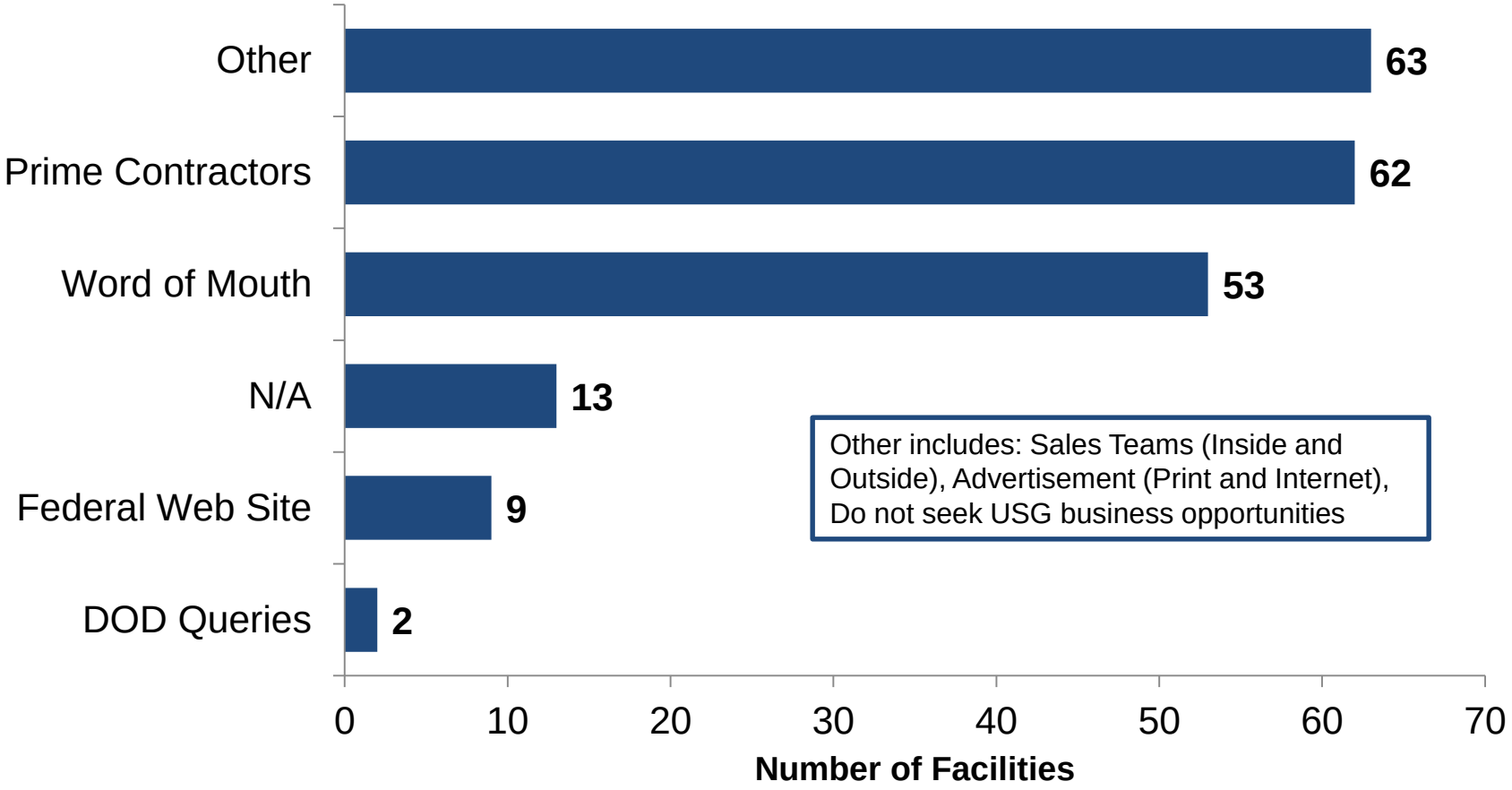
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

USG Programs

Mechanisms for Obtaining U.S. Government Business (2012-2015)

Primary Methods Used to Find USG Business Opportunities



Q3a,A

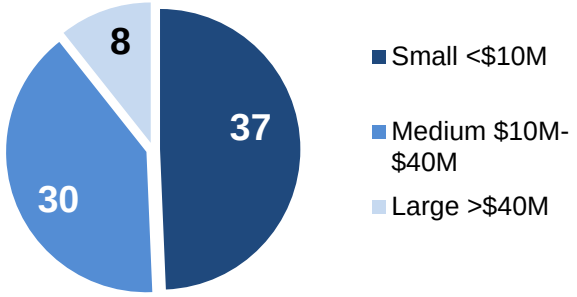
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

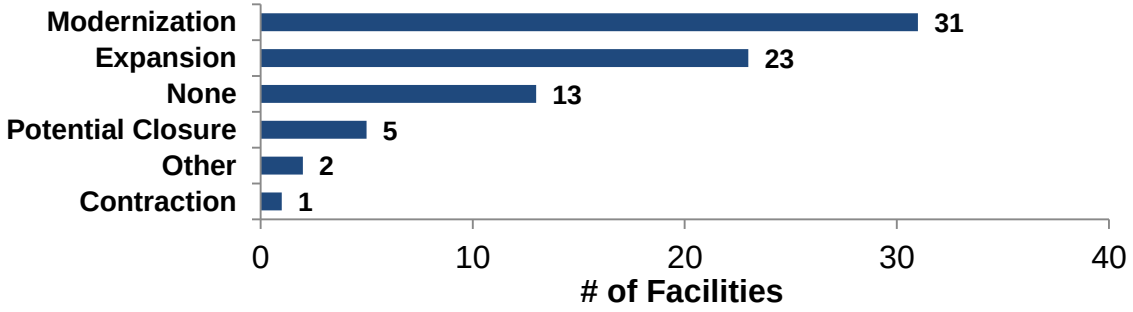
U.S. Air Force

- 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

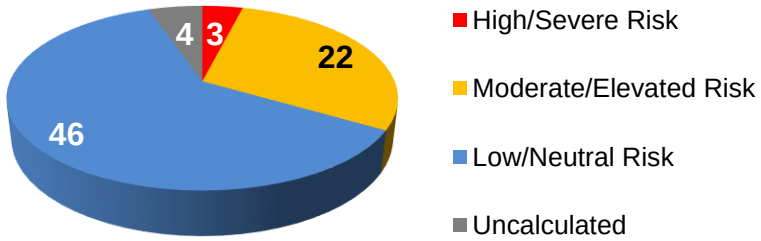
Bare PCB Facility Size by Annual Sales (2015)



Primary Expected Change in Operations 2016-2020



Financial Risk Rating



Top USAF Programs Supported :	
• Joint Strike Fighter	• JASSM
• Paveway	• APKWS
• AMRAAM	• F-16
• SDB	• ATFLIR
• MEADS	• F-22
• F-15	• F-35
• Space Fence	

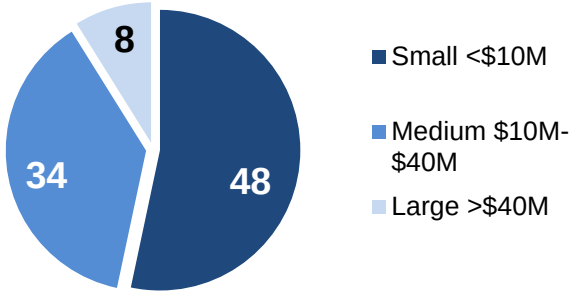
75 Respondents

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

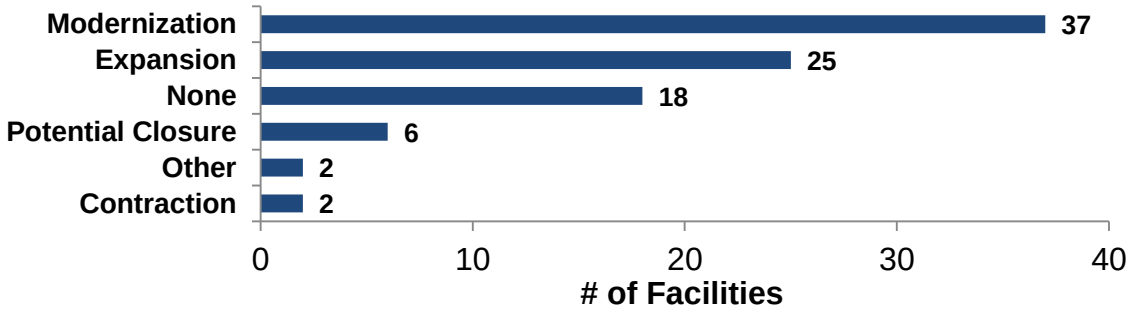
U.S. NAVY

- 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

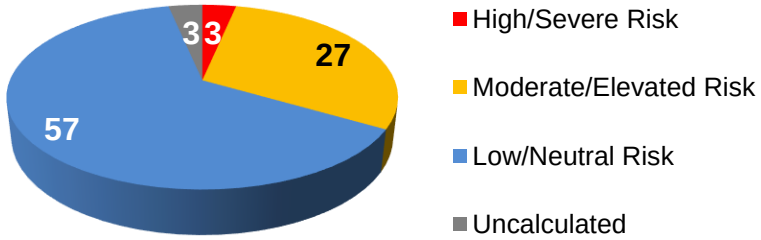
Bare PCB Facility Size by Annual Sales (2015)



Primary Expected Change in Operations 2016-2020



Financial Risk Rating



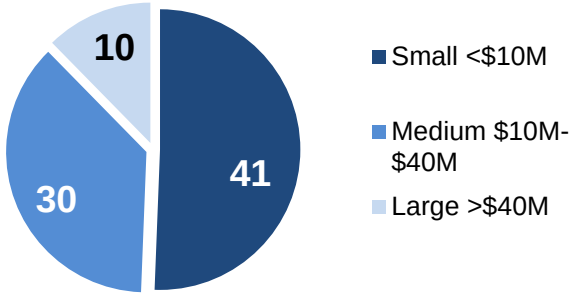
U.S. Navy Programs Supported Include:	
• AMDR	• Naval Undersea Warfare Center
• AGR4	• NLOS Missiles
• F-18	• P8A Poseidon
• F35 Joint Strike Fighter	• SM2
• JDAMs	• Spy3
• MK48	• Standard Missile SM-3
• NAVAL RESEARCH LAB	• TPY-53

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

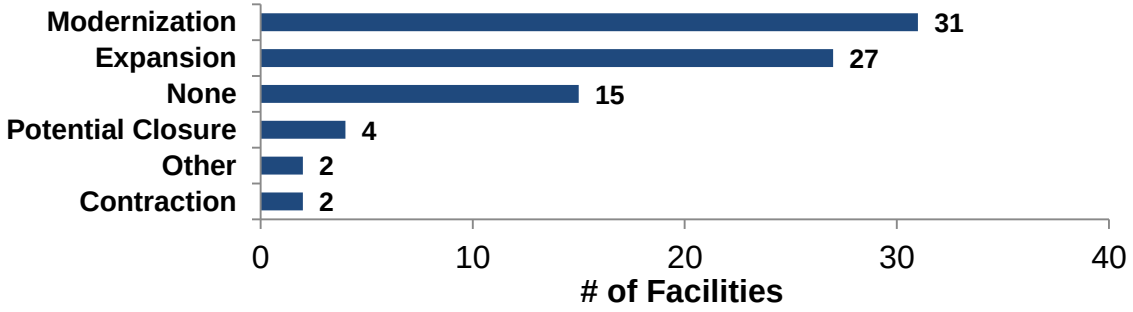
U.S. ARMY

- 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

Bare PCB Facility Size by Annual Sales (2015)



Primary Expected Change in Operations 2016-2020



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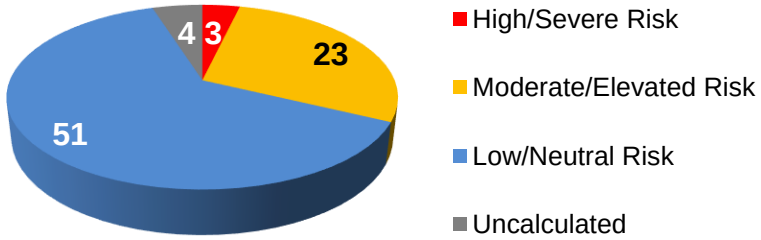


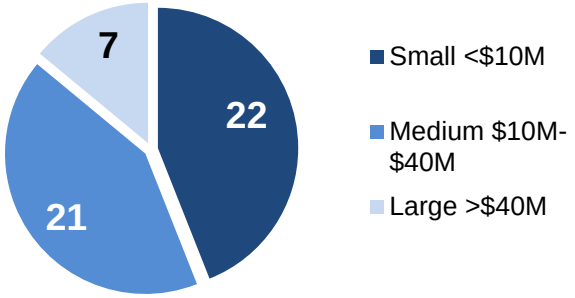
U.S. Army Programs Supported Include:	
• Abrams ECP1	• JAVELIN
• AH-64 Apache	• KIV-77
• BLACKHAWK	• Manpack
• Enhanced Night Vision Goggles	• Missile Defense
• ENVG	• PAC-3
• Excalibur	• Patriot
• Falcon II / III	• THAAD
• GMLRS	• Tomahawk

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

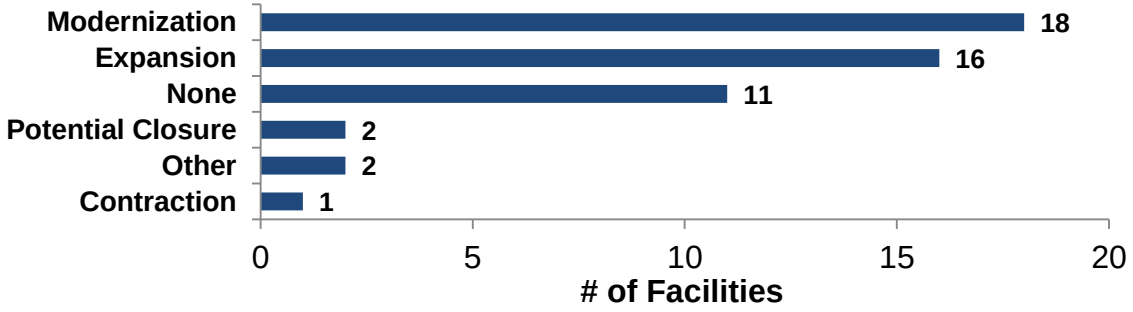
Missile Defense Agency (MDA)

- 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

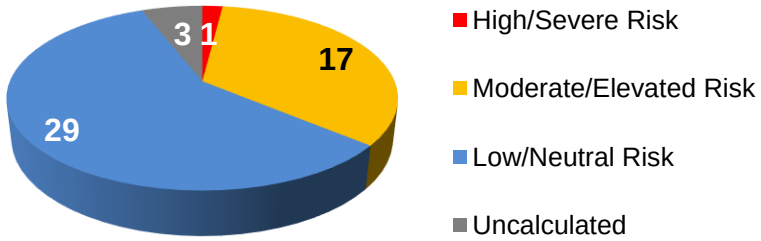
Bare PCB Facility Size by Annual Sales (2015)



Primary Expected Change in Operations 2016-2020



Financial Risk Rating



MDA Programs Supported Include:	
• LRDR	• AMDR
• Space Fence	• CWEB
• Patriot Missiles	• SM2 and SM3 Missile Program
• THAAD Missiles	• THAAD
• Standard Missile 3	• ICBM
• EKV	• ABMD

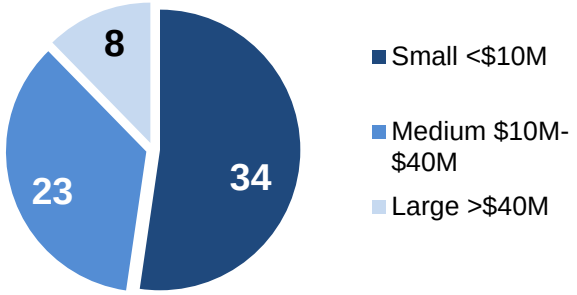
50 Respondents

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

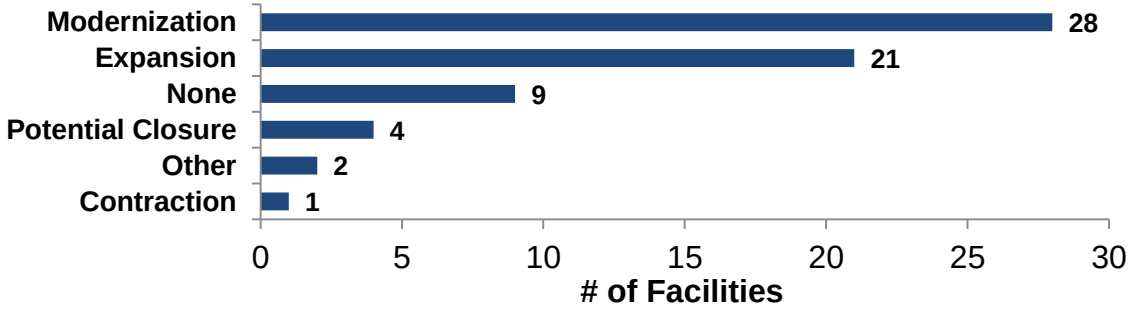
National Aeronautics and Space Administration (NASA)

- 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)



Primary Expected Change in Operations 2016-2020



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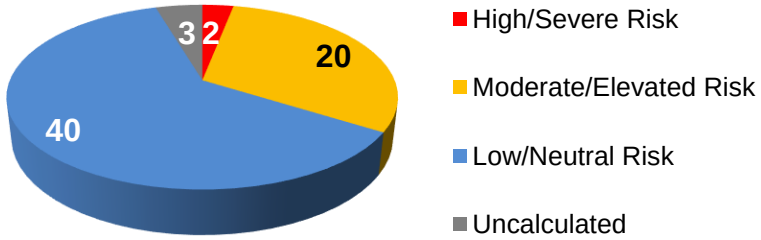


NASA Programs Supported Include:	
• SLS	• Atlas 4
• JUDY FLEX J1-001	• Space Cube
• JUDY FLEX J3-001	• Mars Pathfinder
• SDO	• Mars Curosity
• JSWST	• Mars Rover
• Dragon Capsule	• AEHF
• Orion Crew Vehicle	• GEOS
• MSL Rover	

65 Respondents

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

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

USG Interactions

Facility Dependence on USG Business (2015)

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.

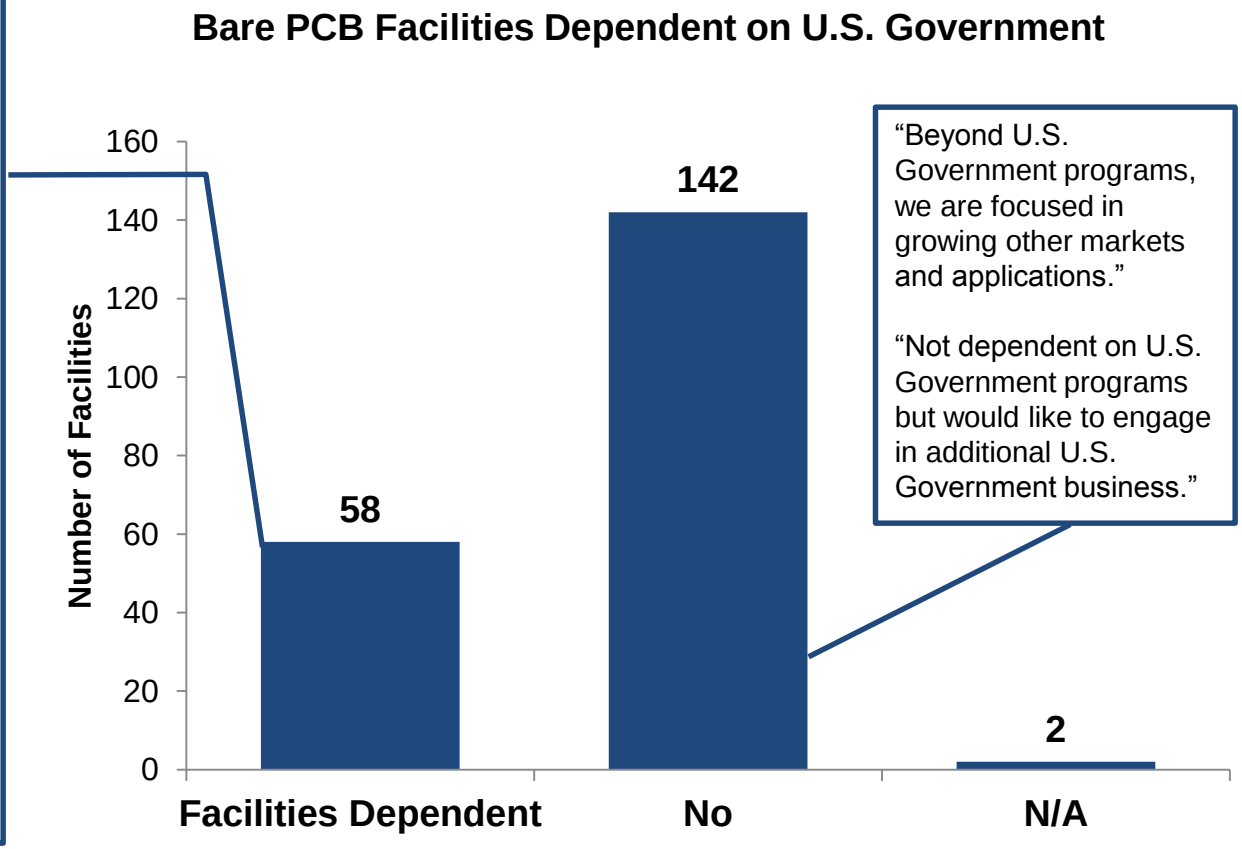
"Absolutely - without our defense work, this facility would not be viable."

"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."



Q4b,A

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

202 respondents

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."

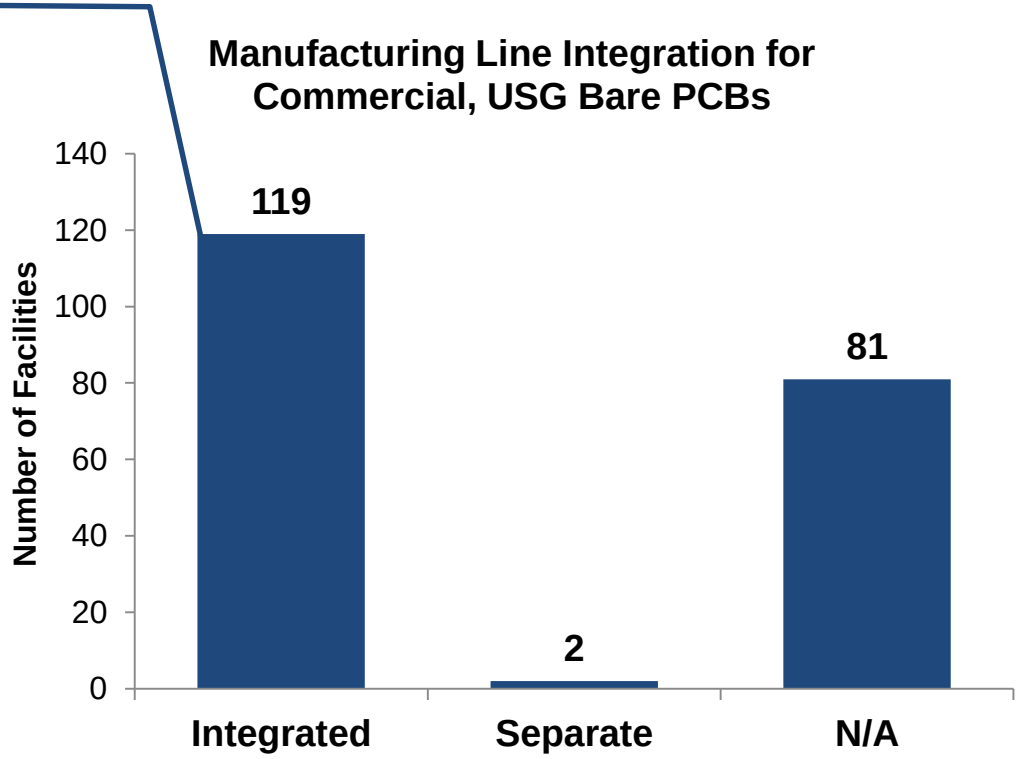
"Products covered by ITAR are kept segregated, but same lines are utilized."

"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."



Q4b,A

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

202 Respondents

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.

Impact of sudden DECREASE in USG Defense Demand			Business Operation	Impact of sudden INCREASE in USG Defense Demand		
No Change or N/A	Decrease	Increase		Increase	Decrease	No Change or N/A
128	66	2	Capital Expenditures	105	1	96
149	48	5	Research & Development Expenditures	62	1	139
129	70	3	Participation in USG Contracts	105	2	95
136	16	50	Product/Service Costs	40	37	125
146	50	6	Organization Viability/Solvency	75	6	121
154	46	2	Personnel with Key Skills	94	2	106
172	26	4	Number of Product/Service Lines	67	1	134
167	3	32	Pursuit of Non-U.S. Customers	7	23	172
170	30	2	Level of Key Production Equipment	97	3	102
188	6	8	Movement of Operations to Non-U.S. Locations	7	5	190

- 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.

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

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 *202 respondents*

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

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.

Impact of sudden DECREASE in USG Defense Demand			Business Operation	Impact of sudden INCREASE in USG Defense Demand		
No Change or N/A	Decrease	Increase		Increase	Decrease	No Change or N/A
128	66	2	Capital Expenditures	105	1	96

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."

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

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.

Impact of sudden DECREASE in USG Defense Demand			Business Operation	Impact of sudden INCREASE in USG Defense Demand		
No Change or N/A	Decrease	Increase		Increase	Decrease	No Change or N/A
149	48	5	Research & Development Expenditures	62	1	139

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."

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
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.

Impact of sudden DECREASE in USG Defense Demand			Business Operation	Impact of sudden INCREASE in USG Defense Demand		
No Change or N/A	Decrease	Increase		Increase	Decrease	No Change or N/A
146	50	6	Organization Viability/Solvency	75	6	121

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."

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
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.

Impact of sudden DECREASE in USG Defense Demand			Business Operation	Impact of sudden INCREASE in USG Defense Demand		
No Change or N/A	Decrease	Increase		Increase	Decrease	No Change or N/A
170	30	2	Level of Key Production Equipment	97	3	102

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."

Q4b,B

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

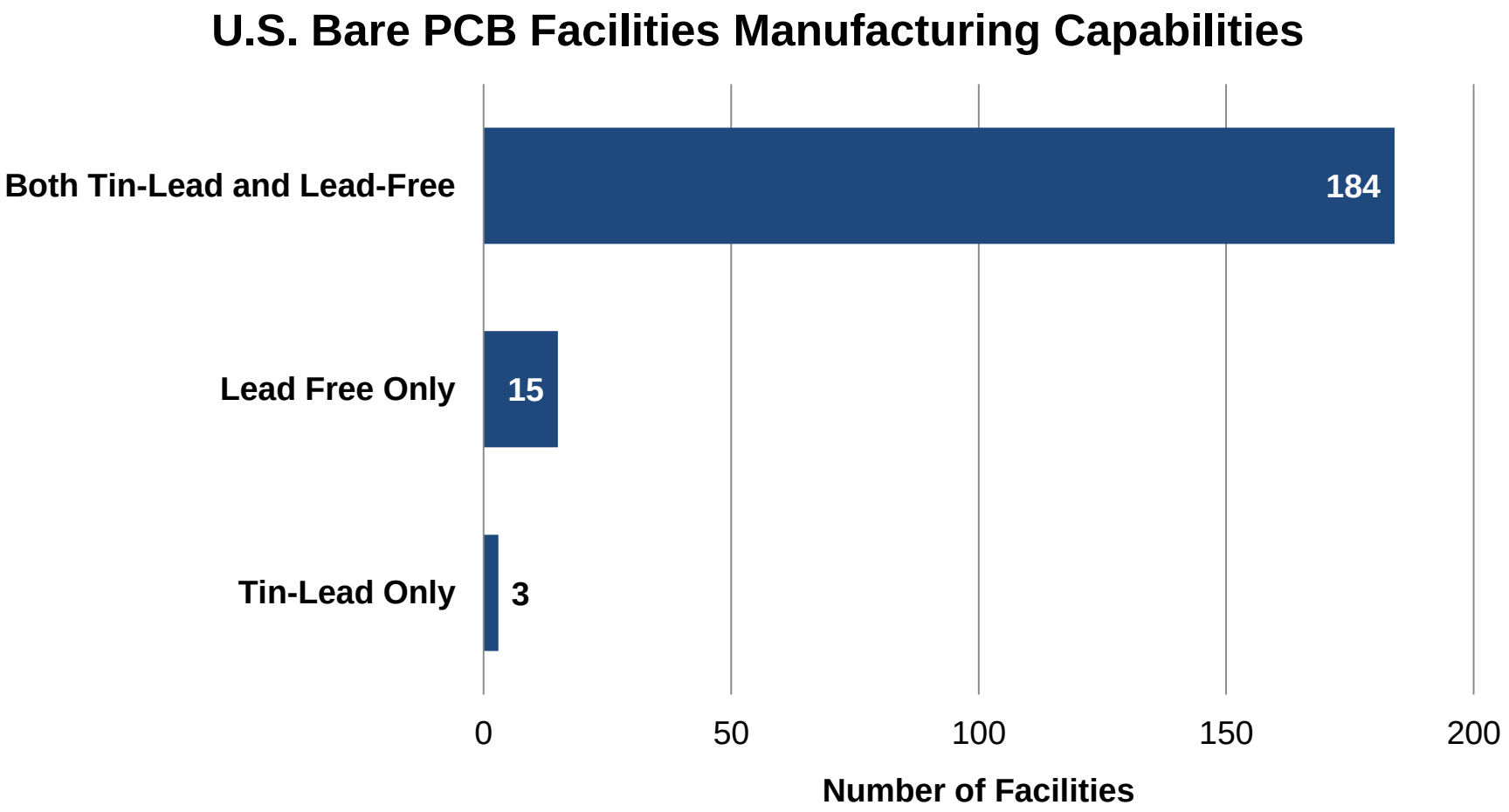
202 Respondents

CHAPTER 4:
BARE PCB MANUFACTURING

- MANUFACTURING CAPABILITIES
- MANUFACTURING STANDARDS
- MANUFACTURING PRODUCTION AND CAPACITY

Facility Manufacturing Capabilities

Types of Boards: Tin Lead/Lead Free (2015)



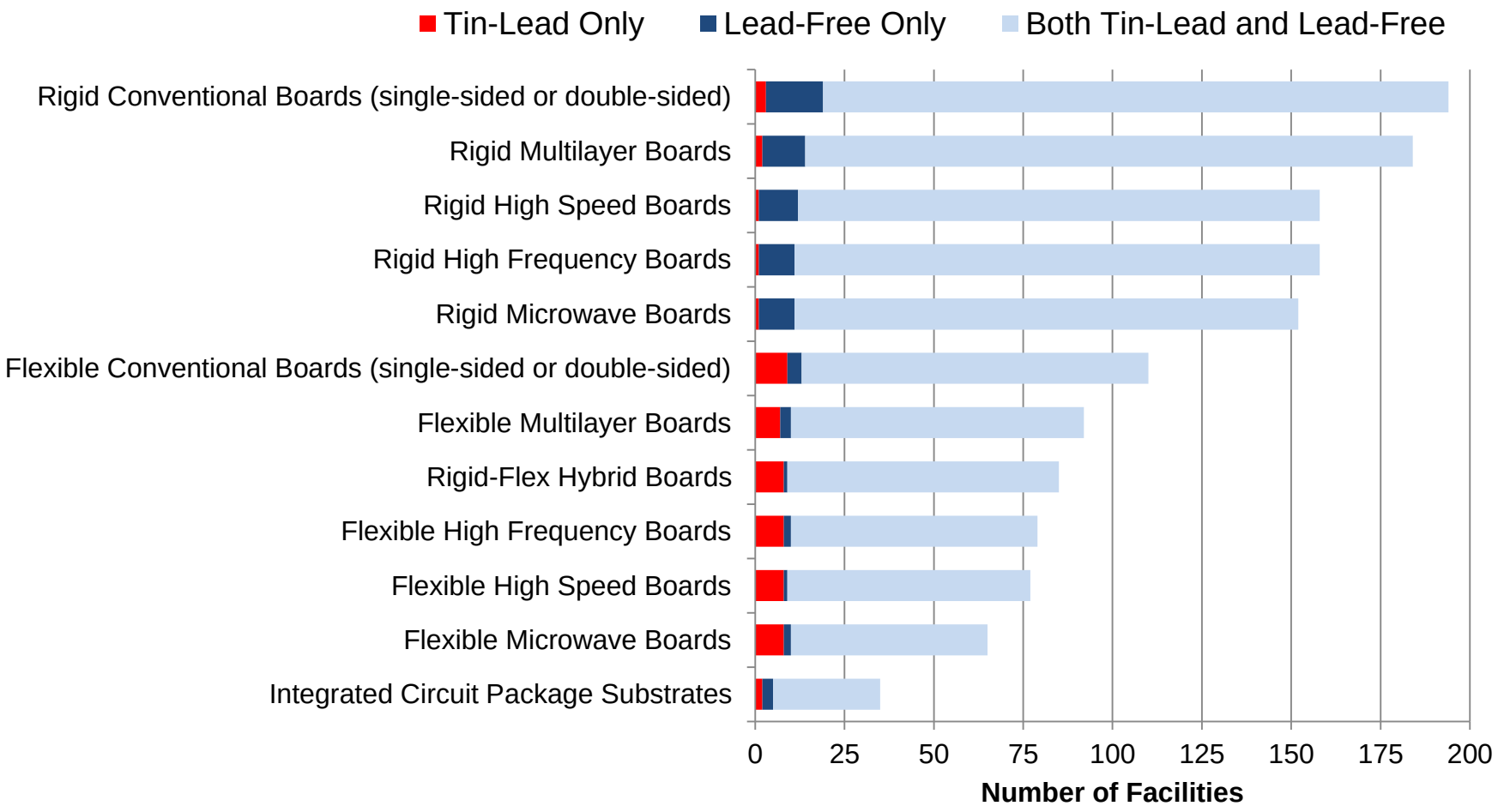
Q5a,A

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

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



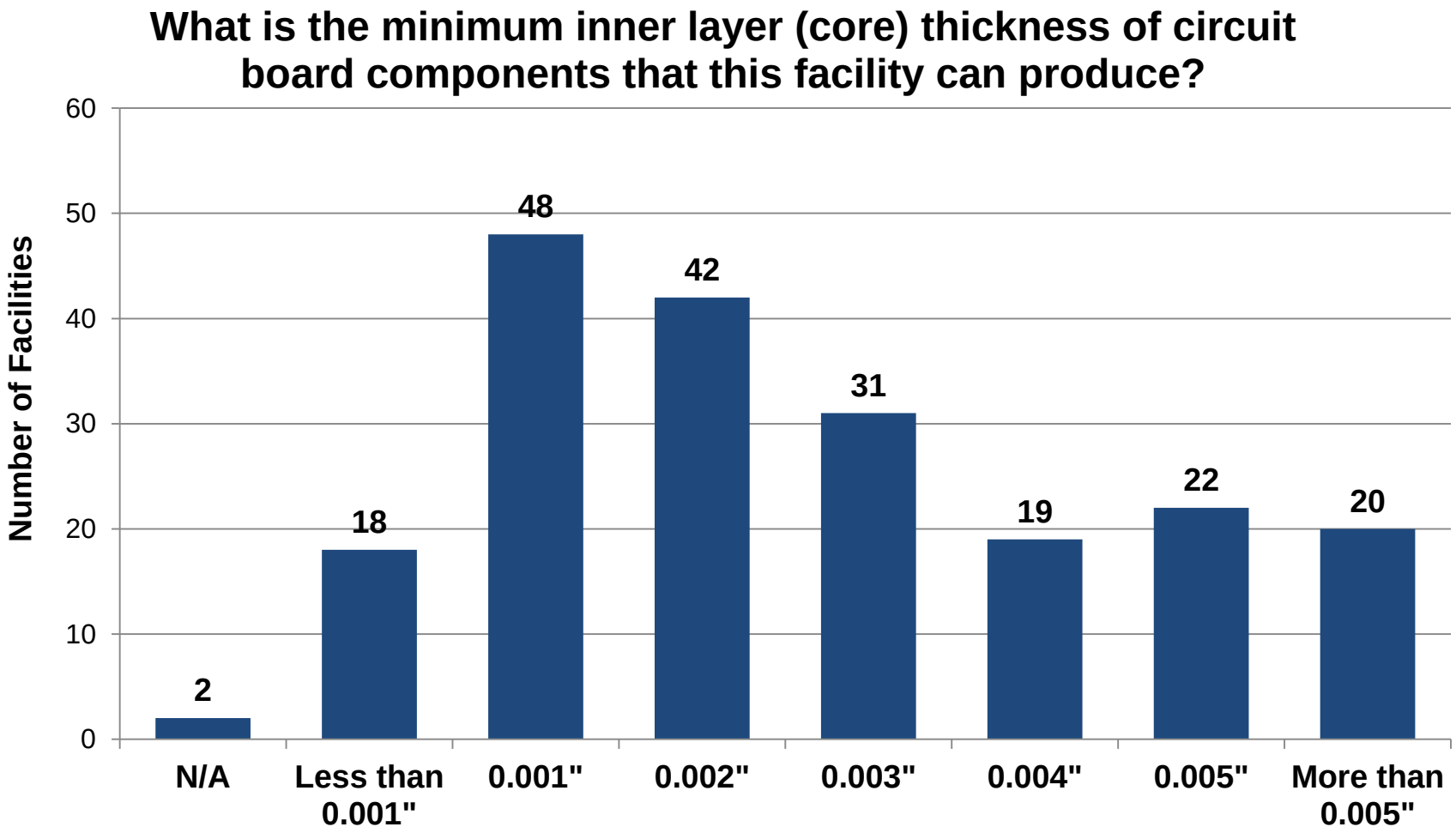
Q5a,A

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

Minimum Bare PCB Inner Layer (Core) Thickness (2015)

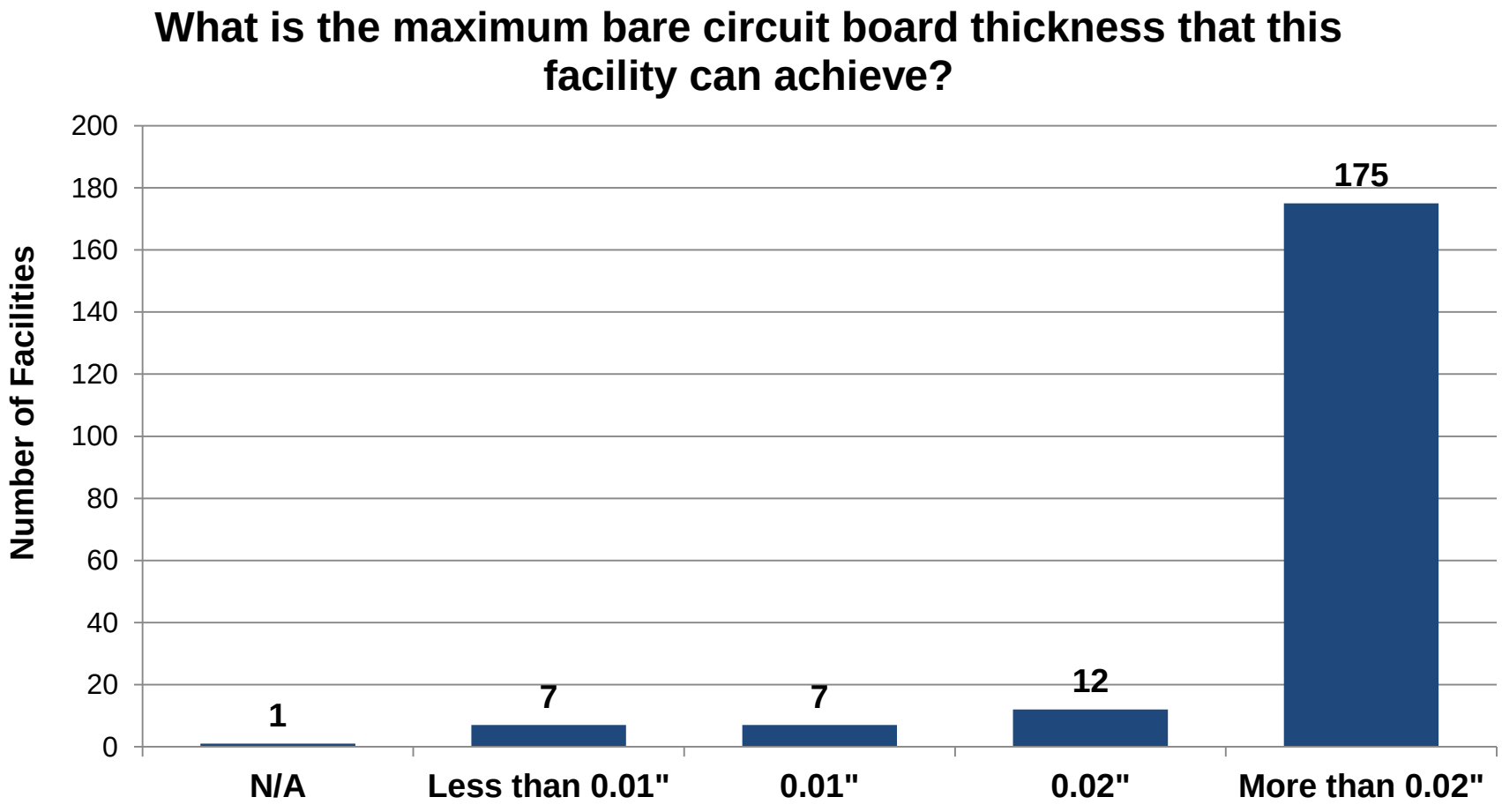


Q5a,B

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)



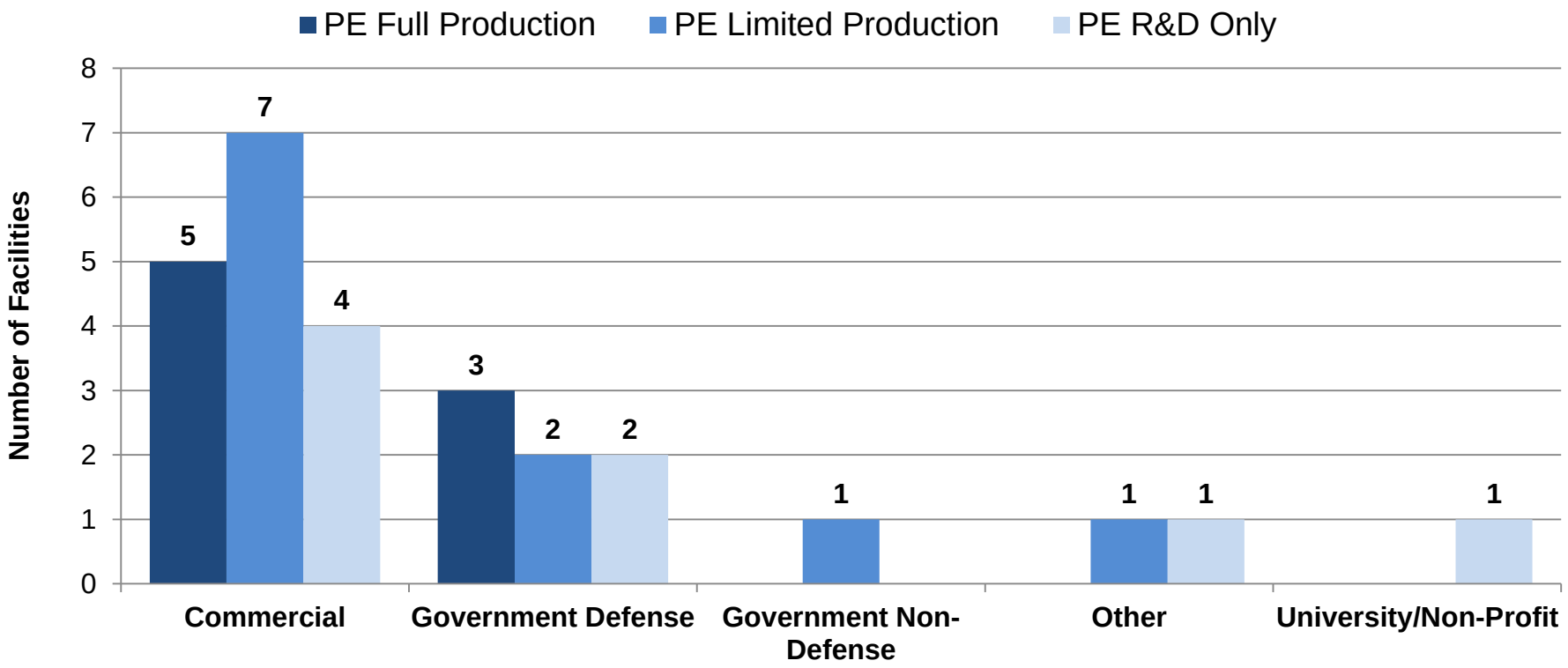
Q5a,B

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.



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

Printed Electronics (PE): Comments

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

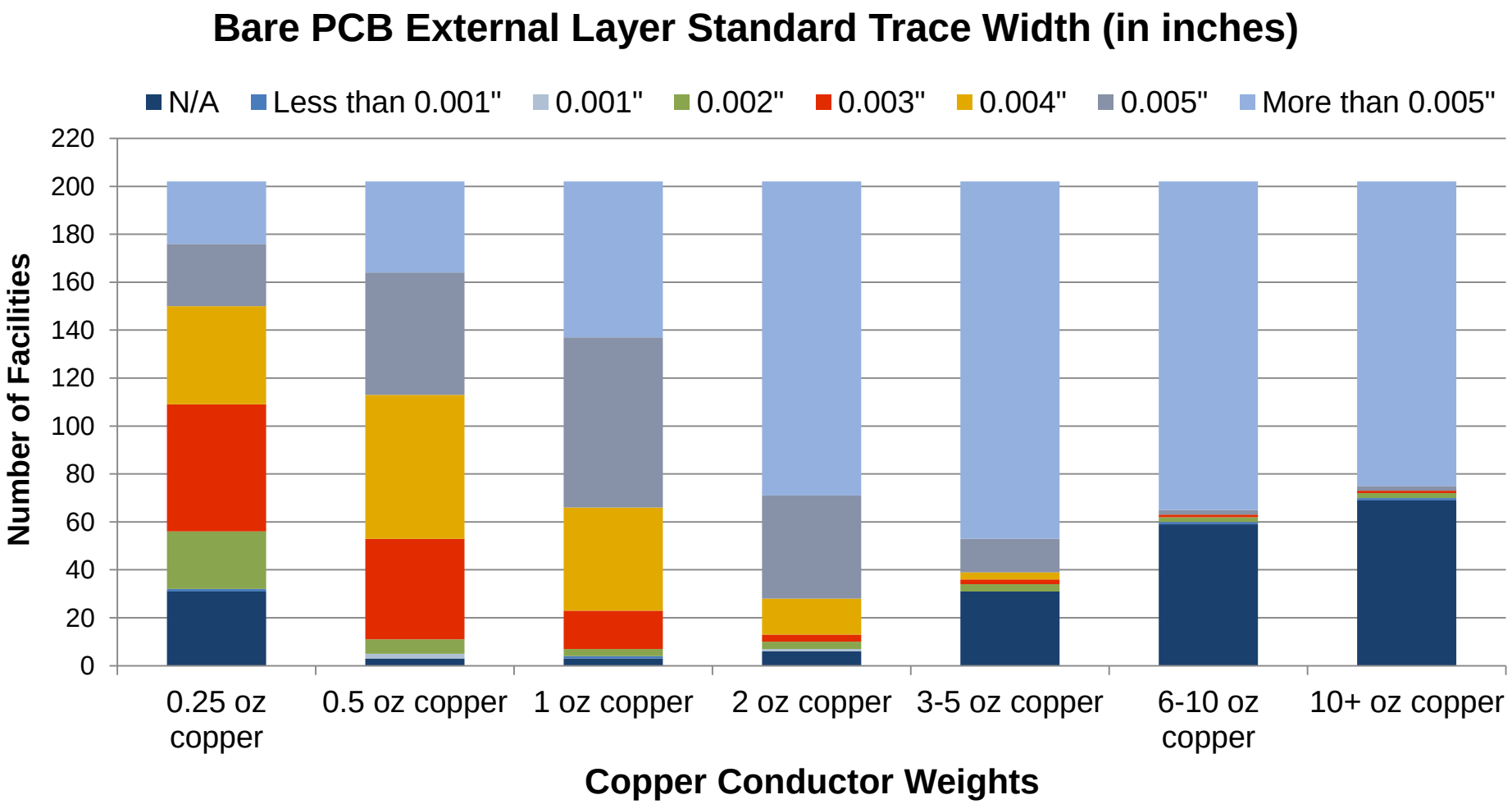
Q5a,C

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

External Layer: Standard Trace Width (2015)



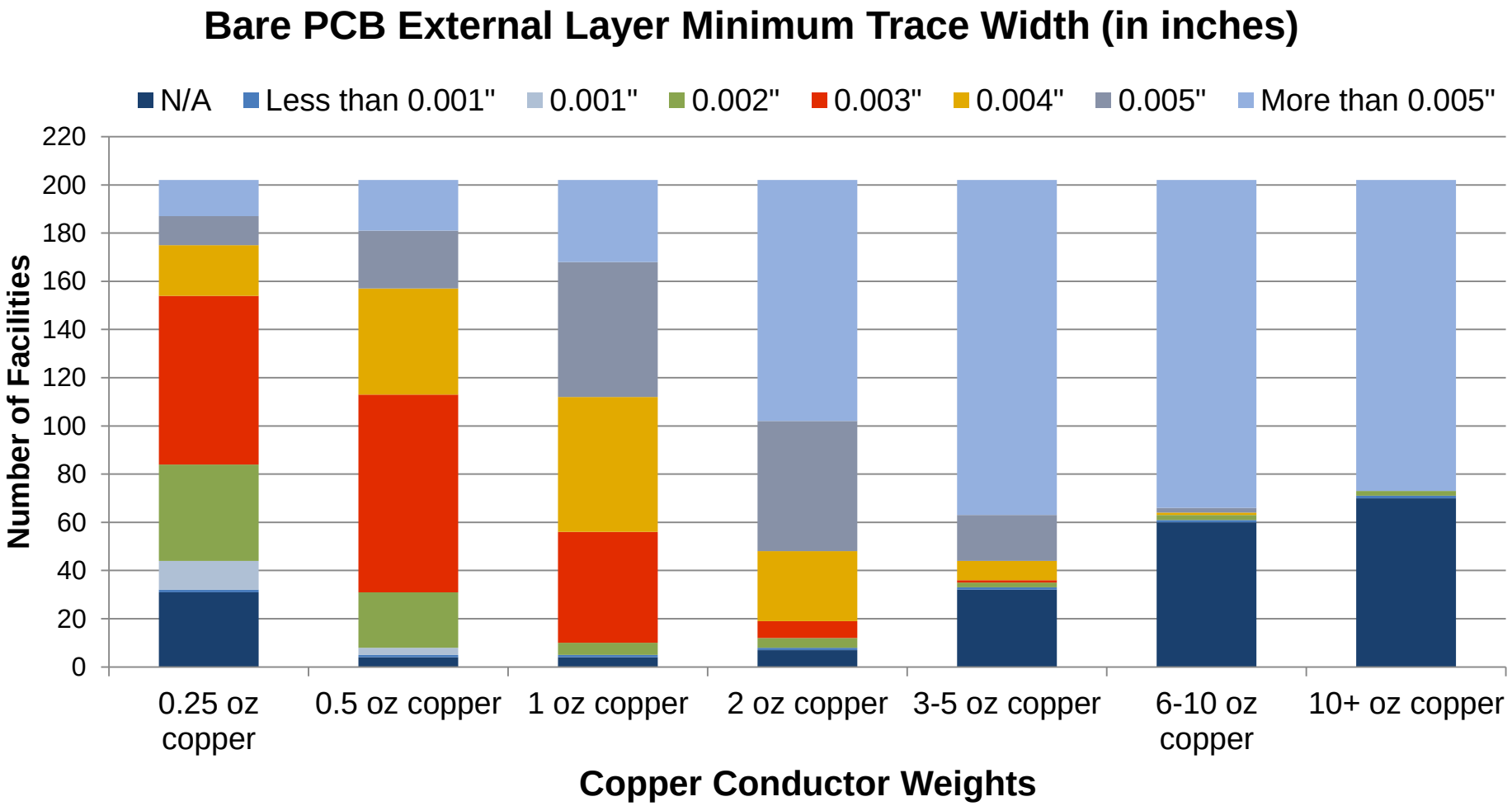
Q5a,D

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

External Layer: Minimum Trace Width (2015)

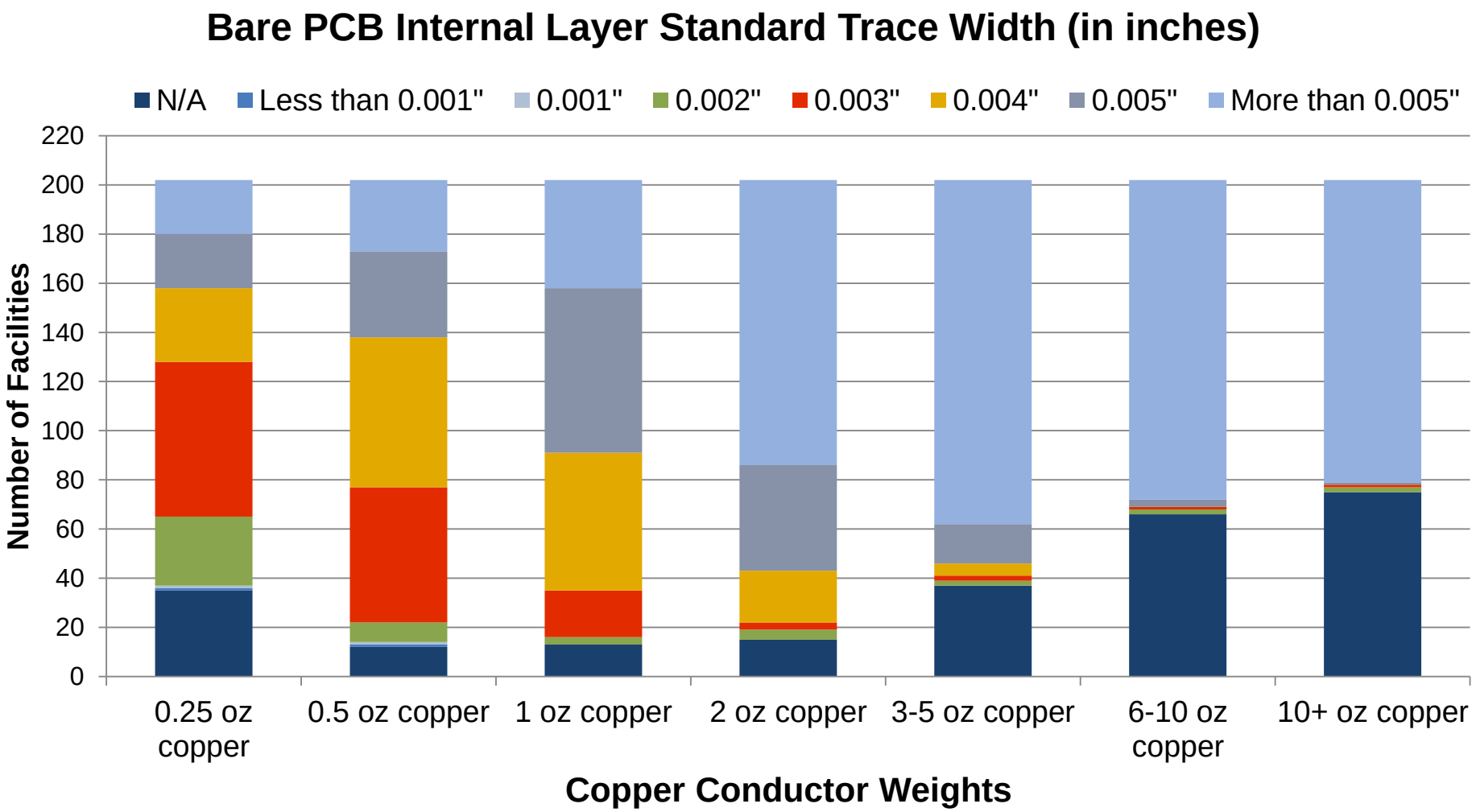


Q5a,D

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
Internal Layer: Standard Trace Width (2015)



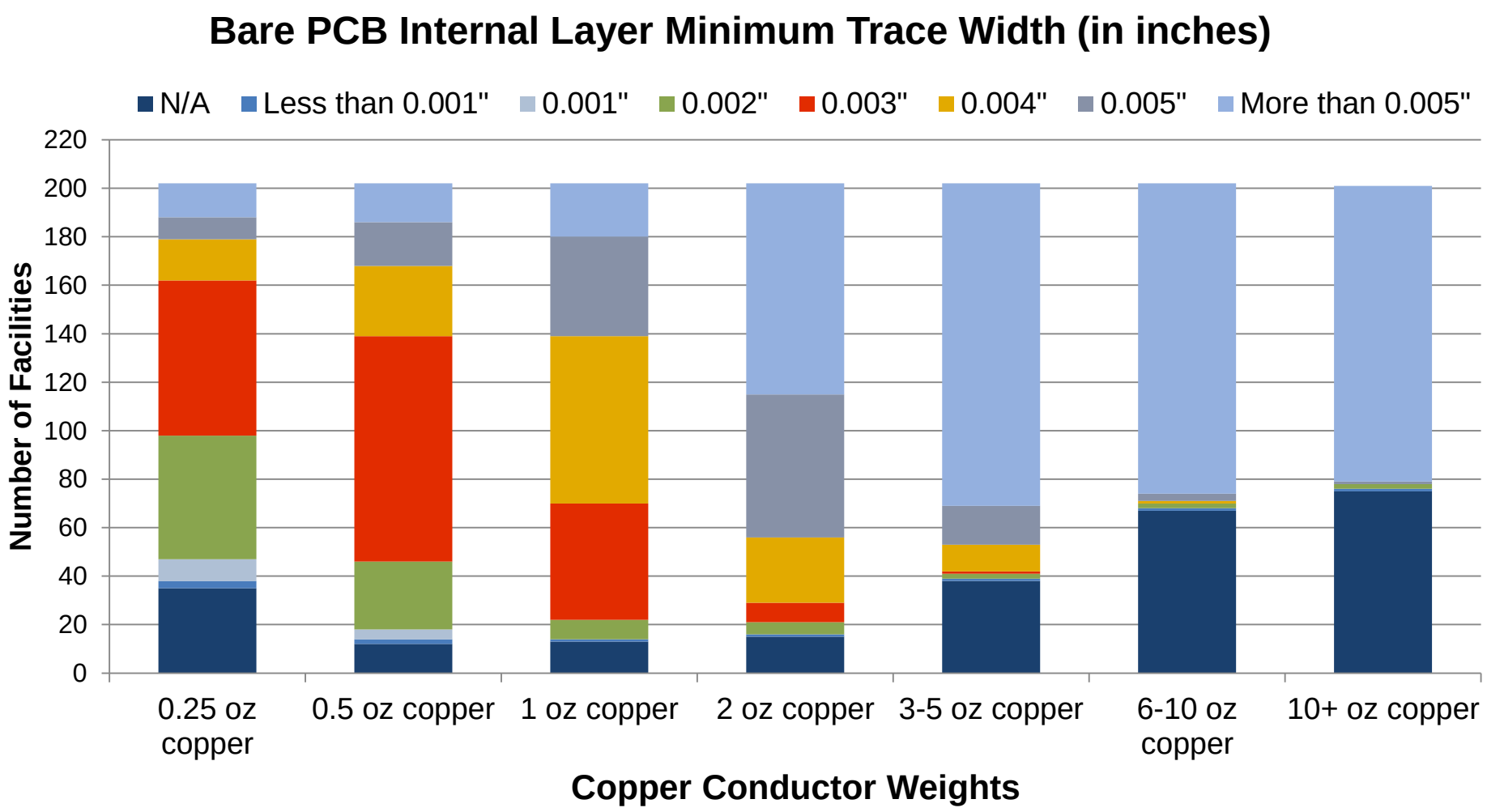
Q5a,D

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

Internal Layer: Minimum Trace Width (2015)



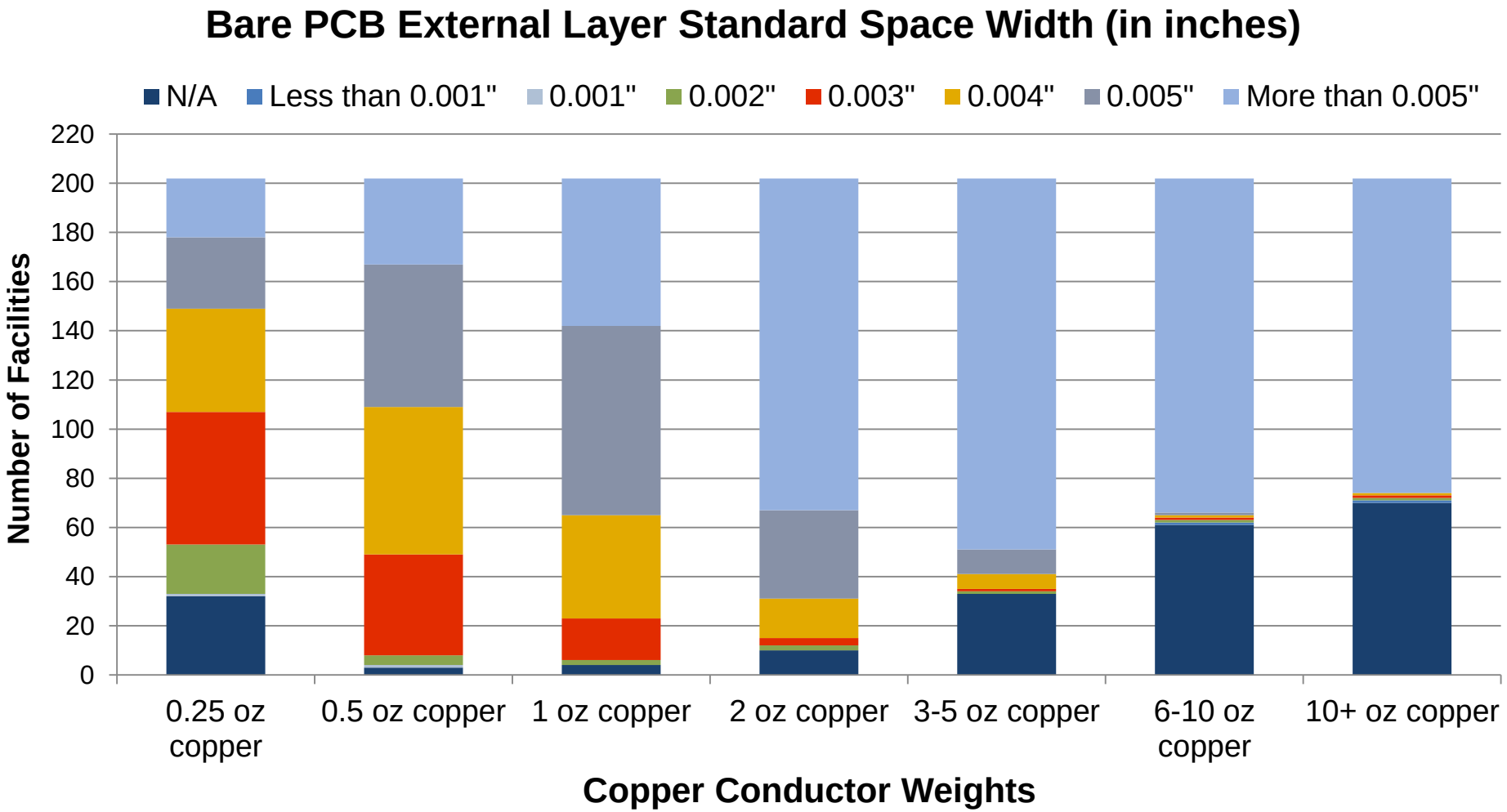
Q5a,D

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

External Layer: Standard Space Width (2015)



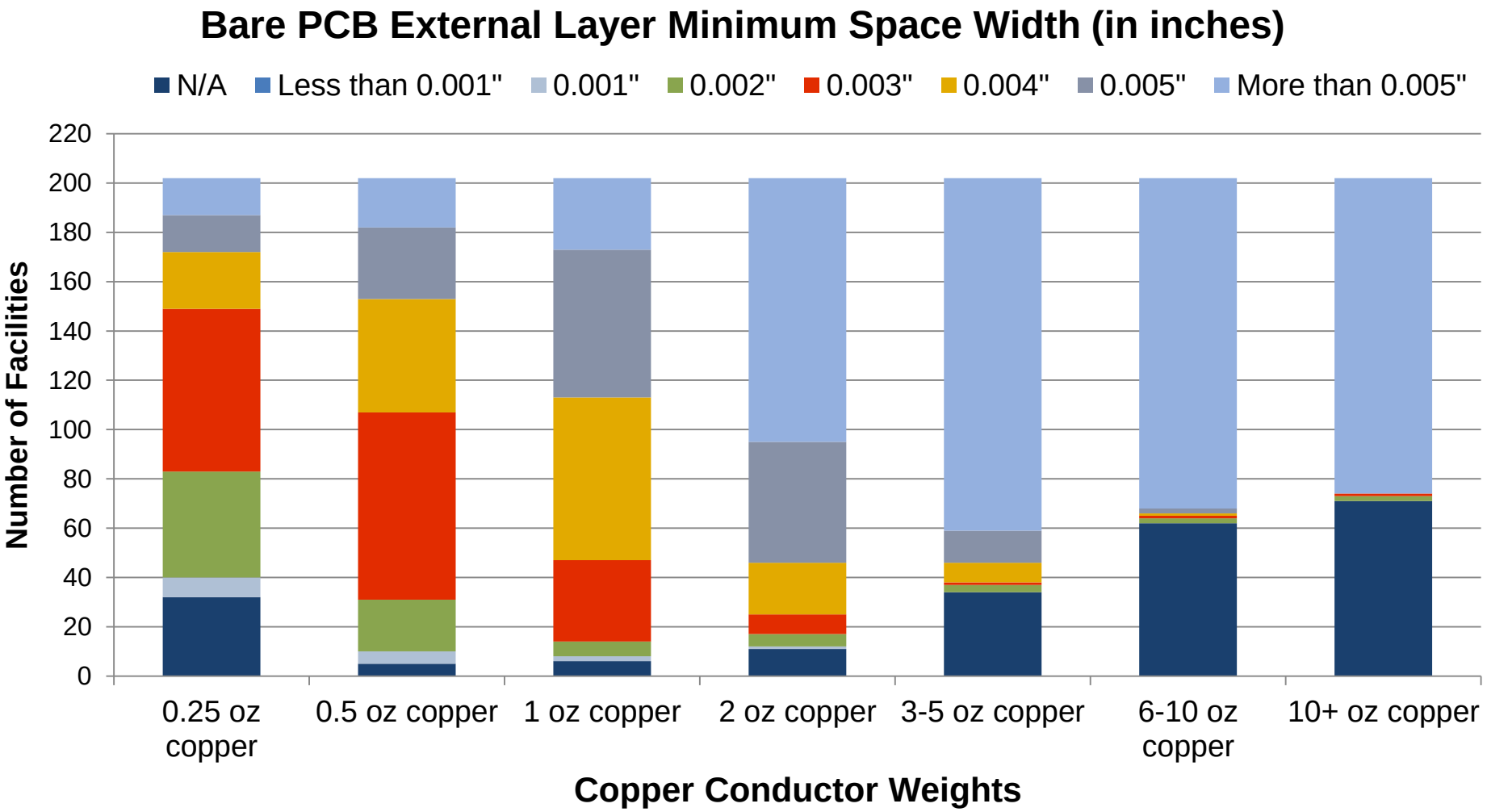
Q5a,E

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

External Layer: Minimum Space Width (2015)



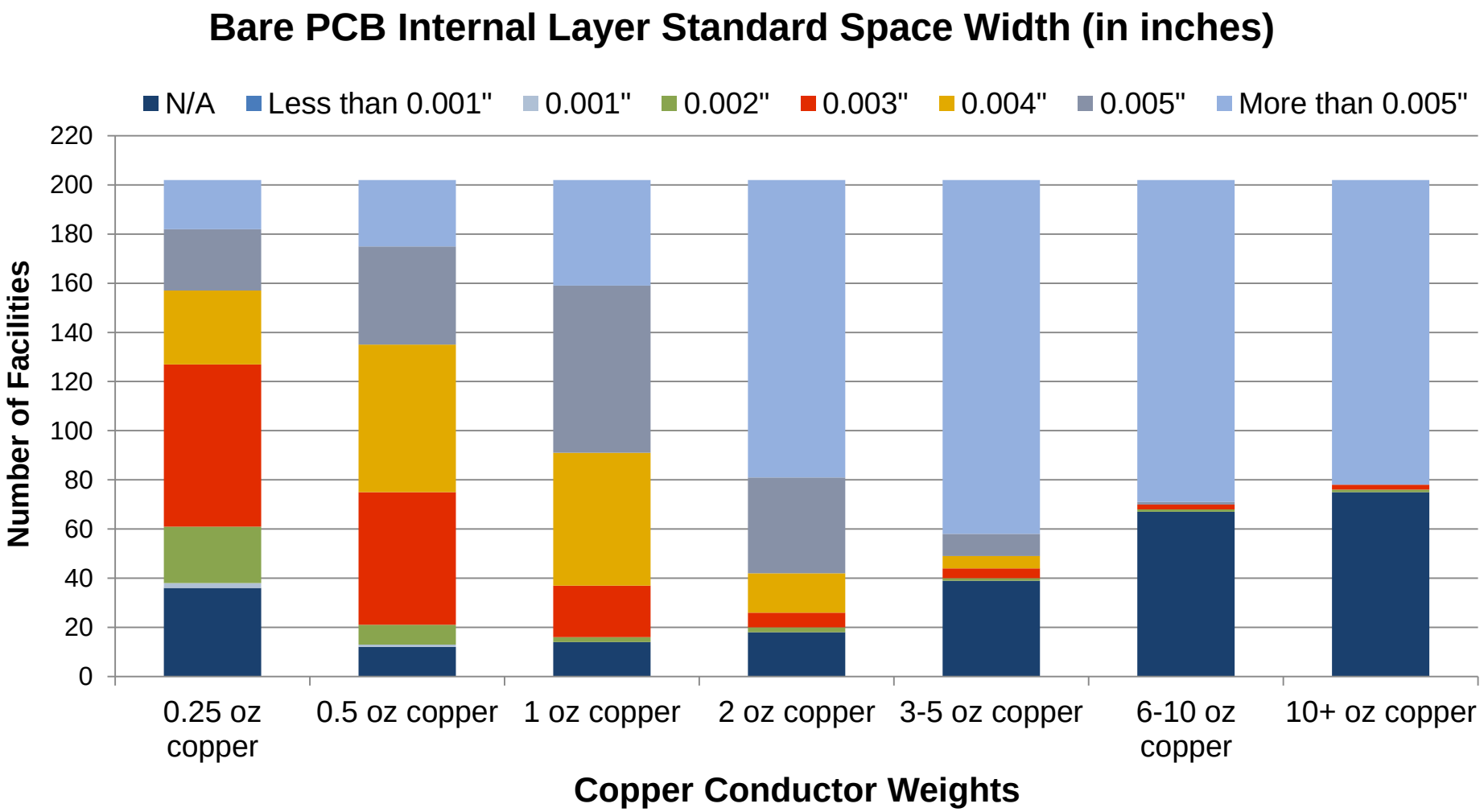
Q5a,E

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: Standard Space Width (2015)

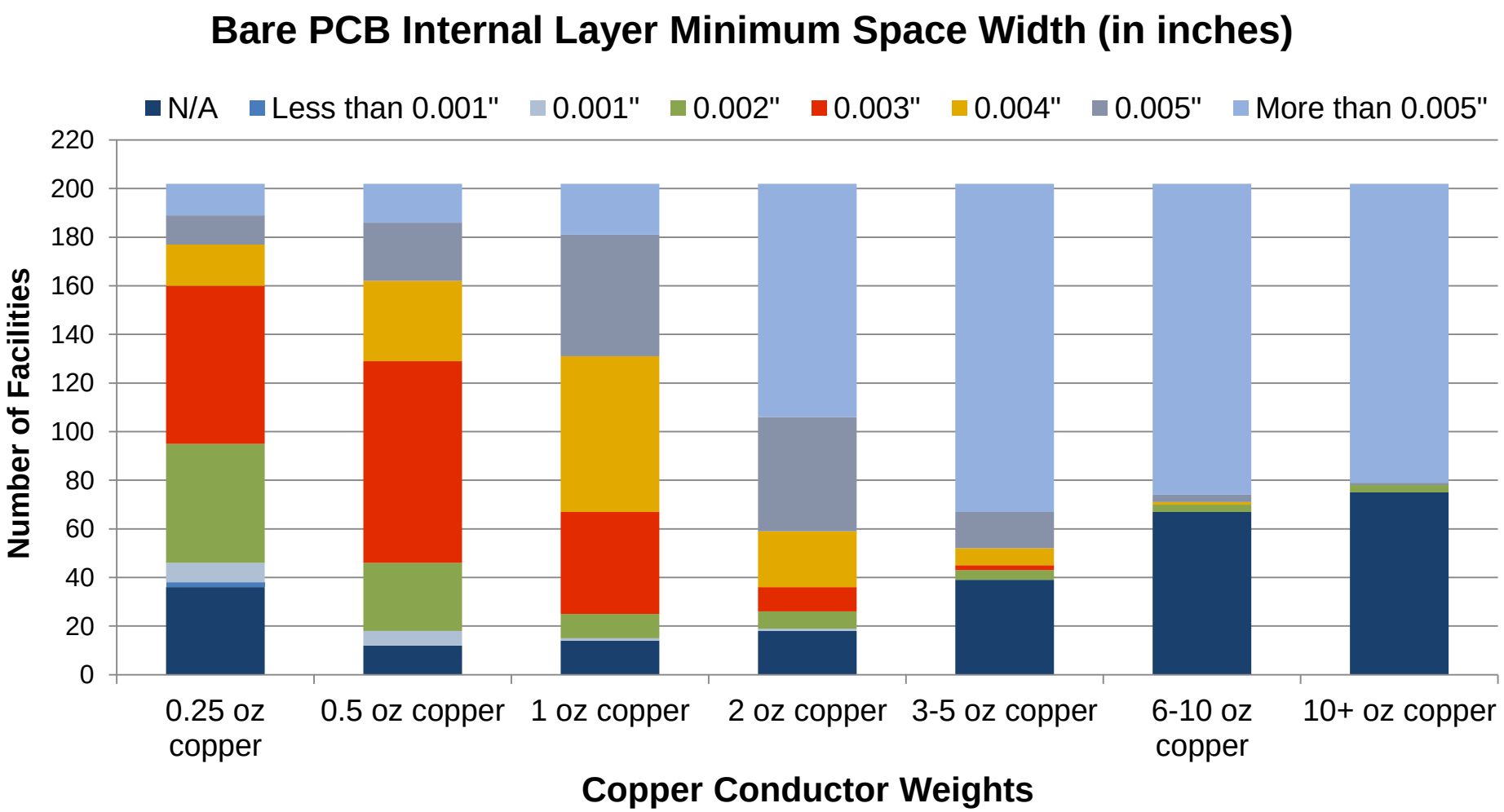


Q5a,E

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)

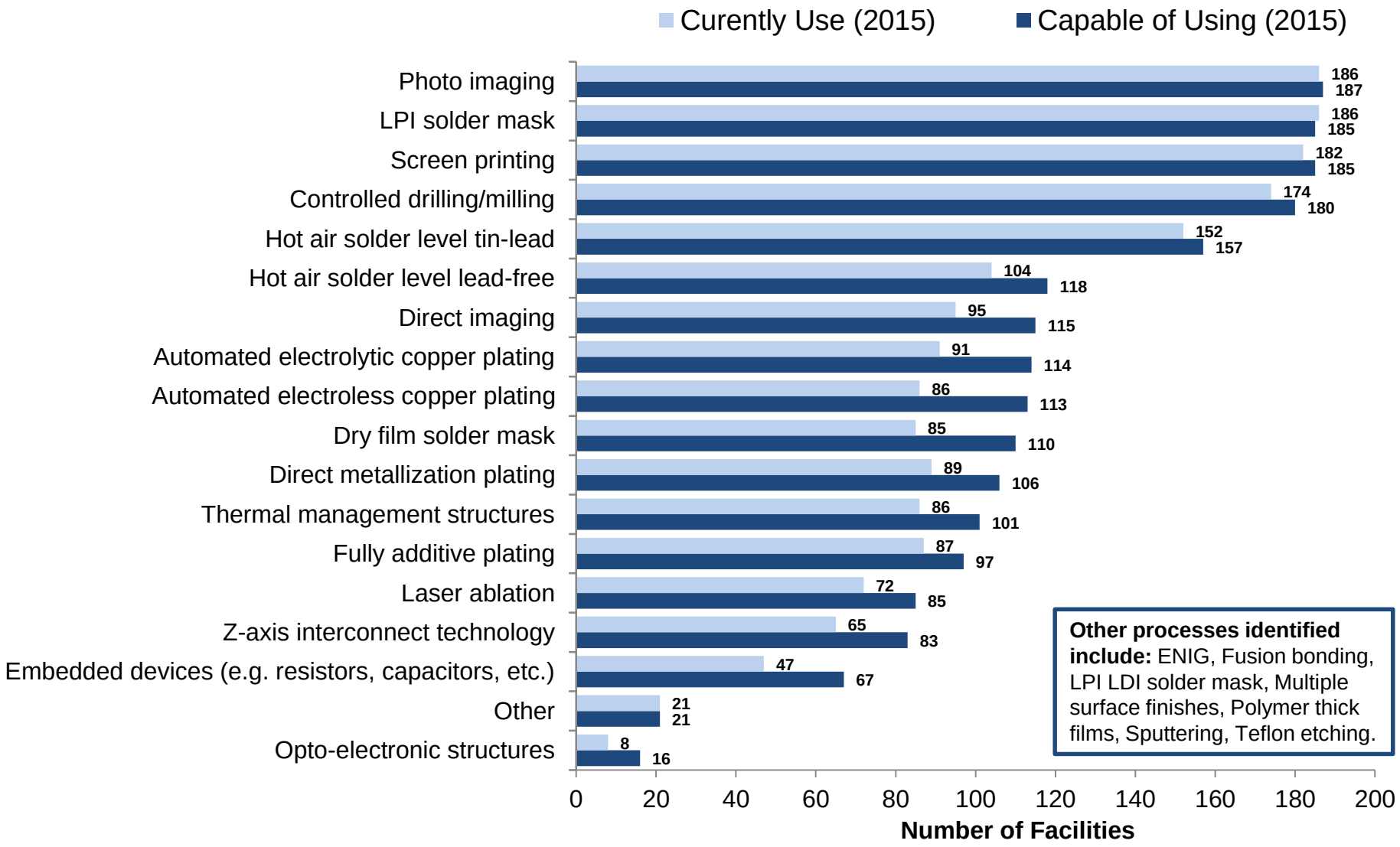


Q5a,E

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



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

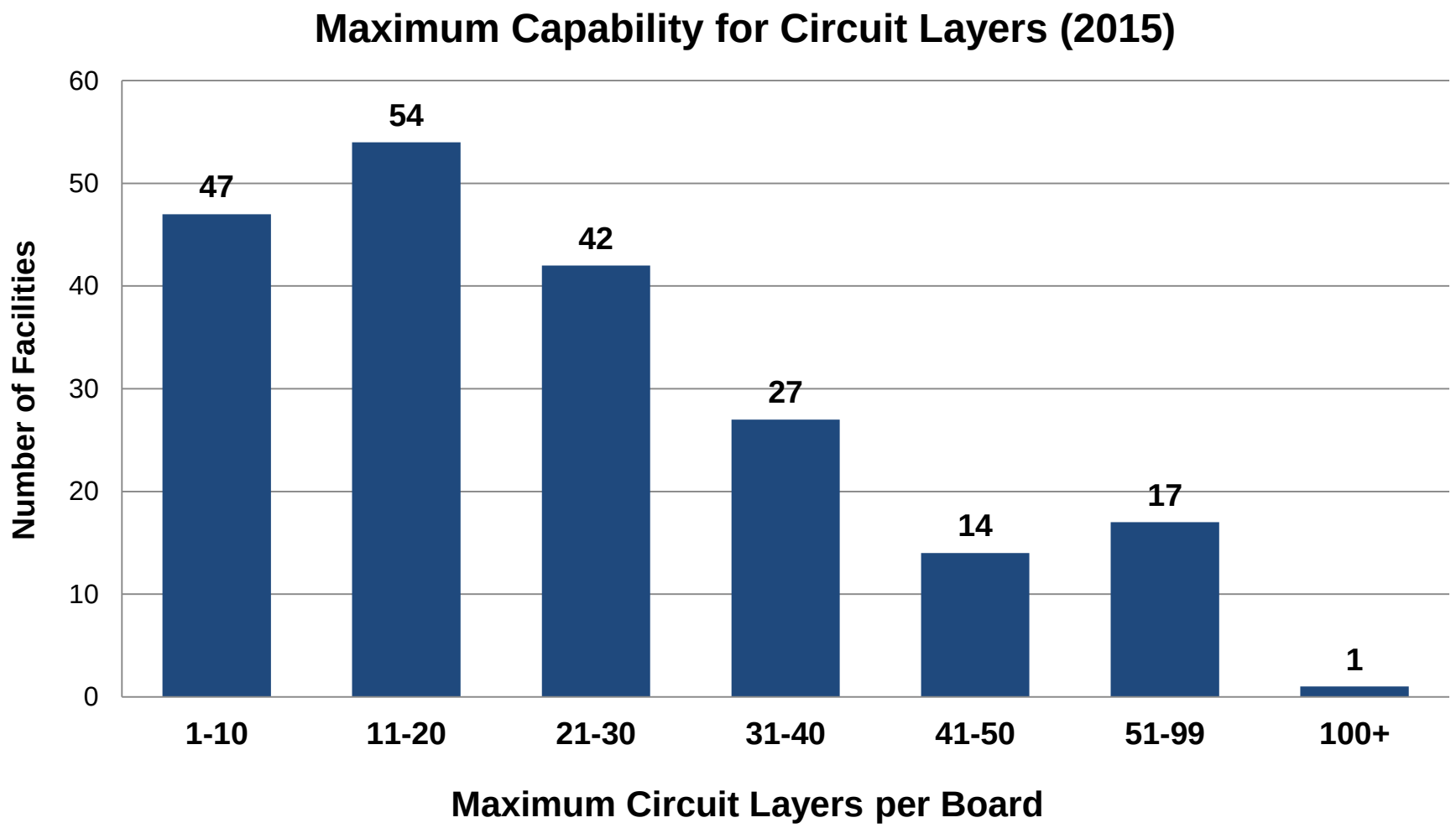
Q5b,A

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

Maximum Circuit Layers per Board



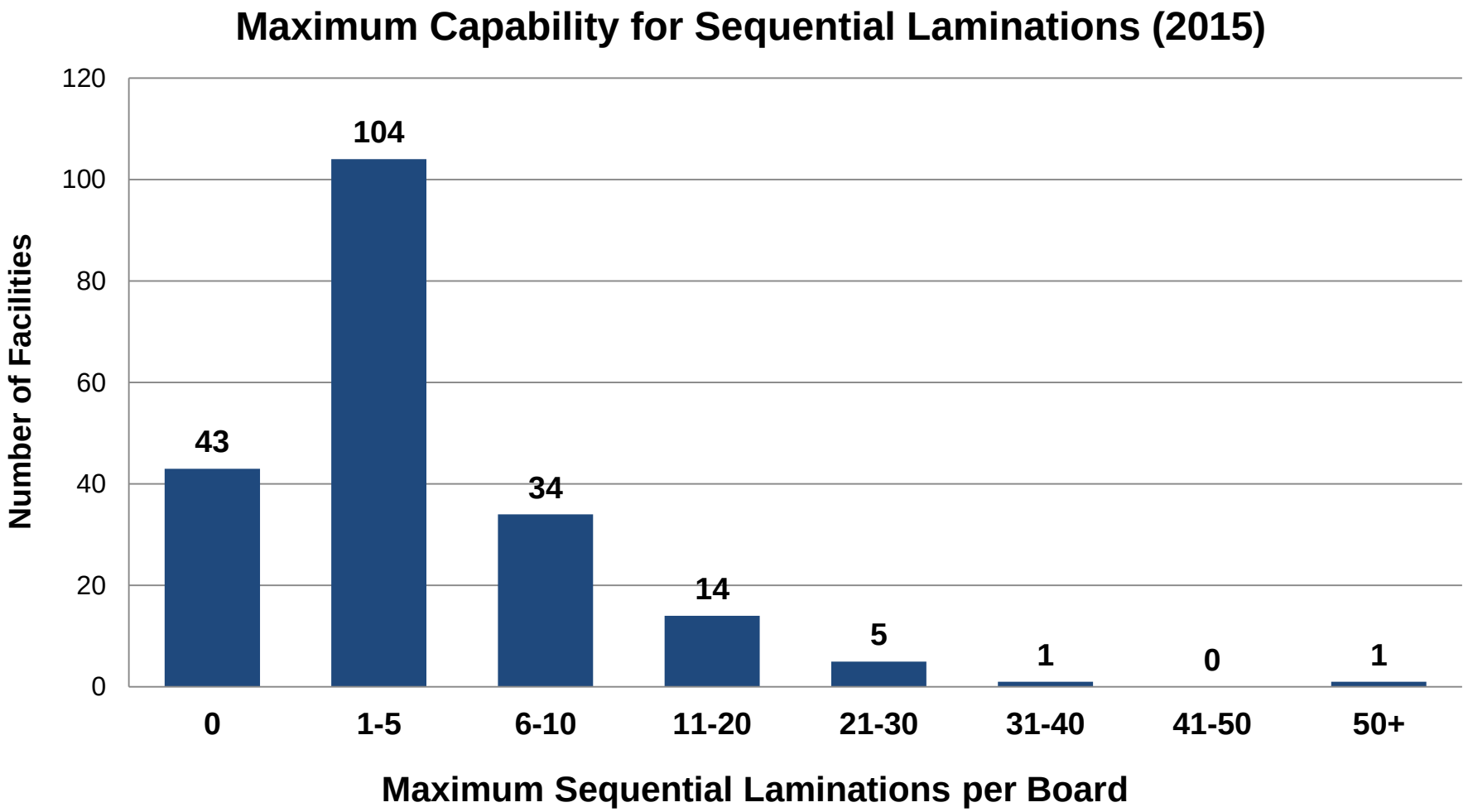
Q5b,B

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 Sequential Laminations per Board



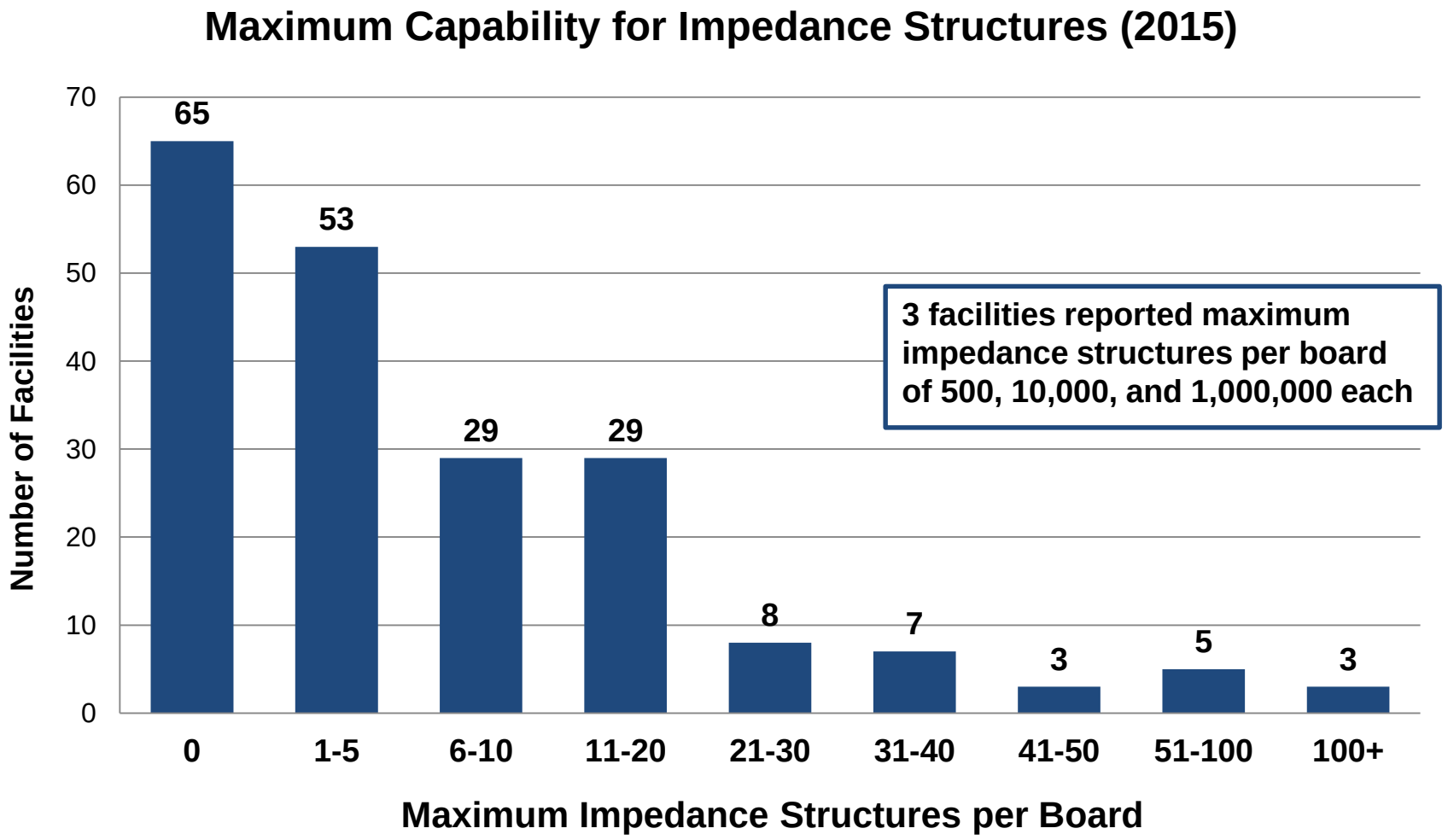
Q5b,B

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 Impedance Structures per Board



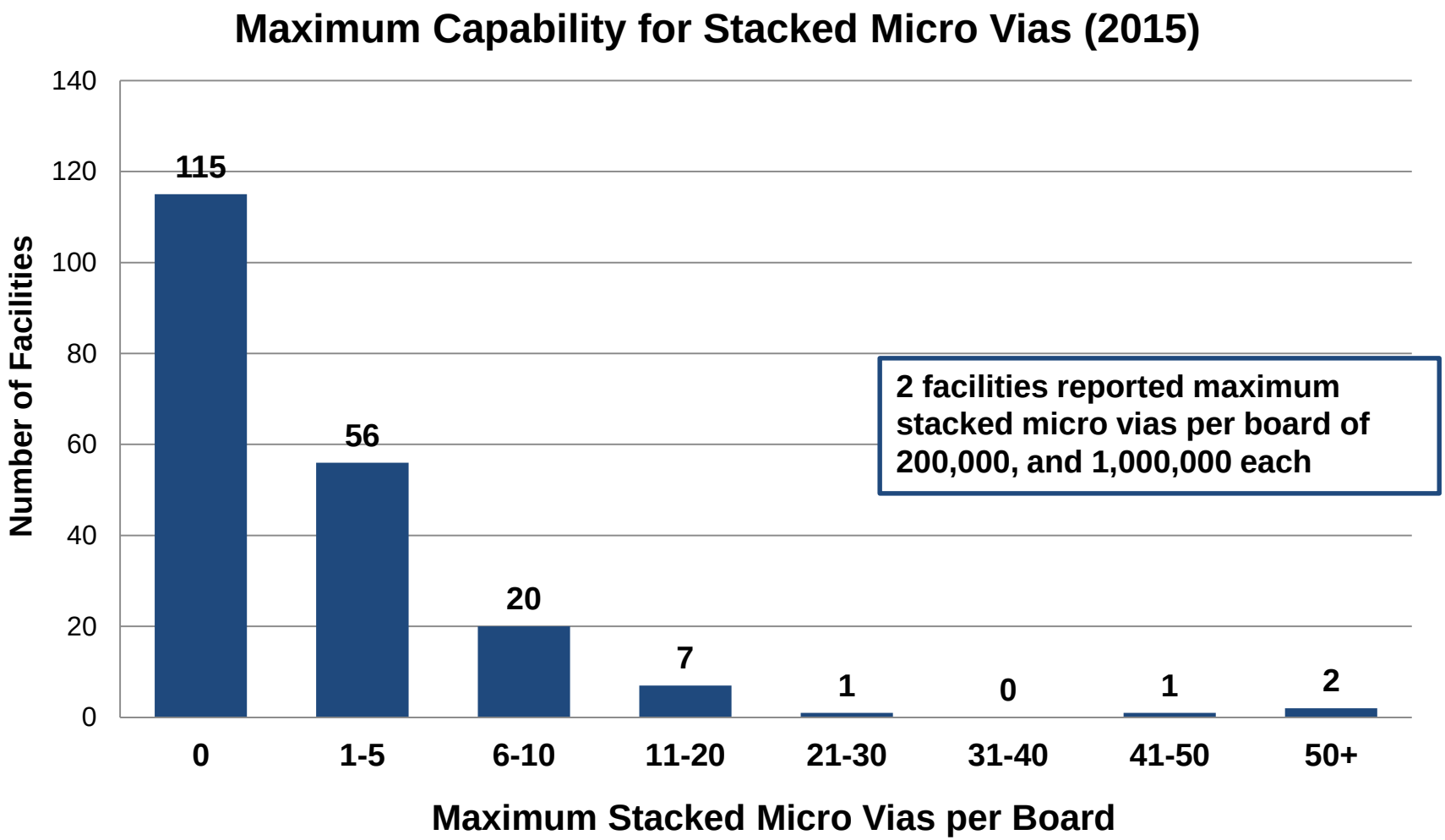
Q5b,B

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



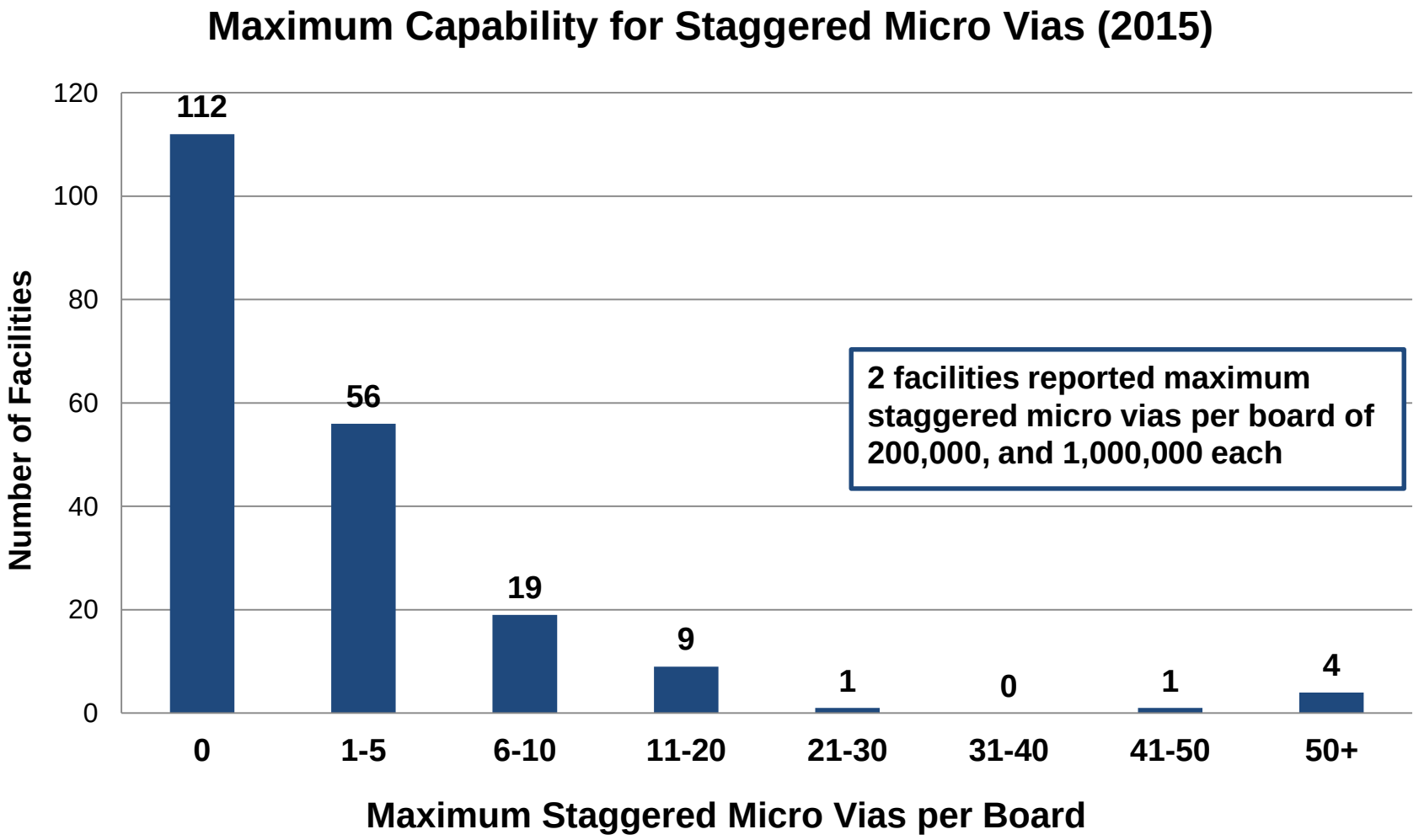
Q5b,B

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 Staggered Micro Vias per Board



Q5b,B

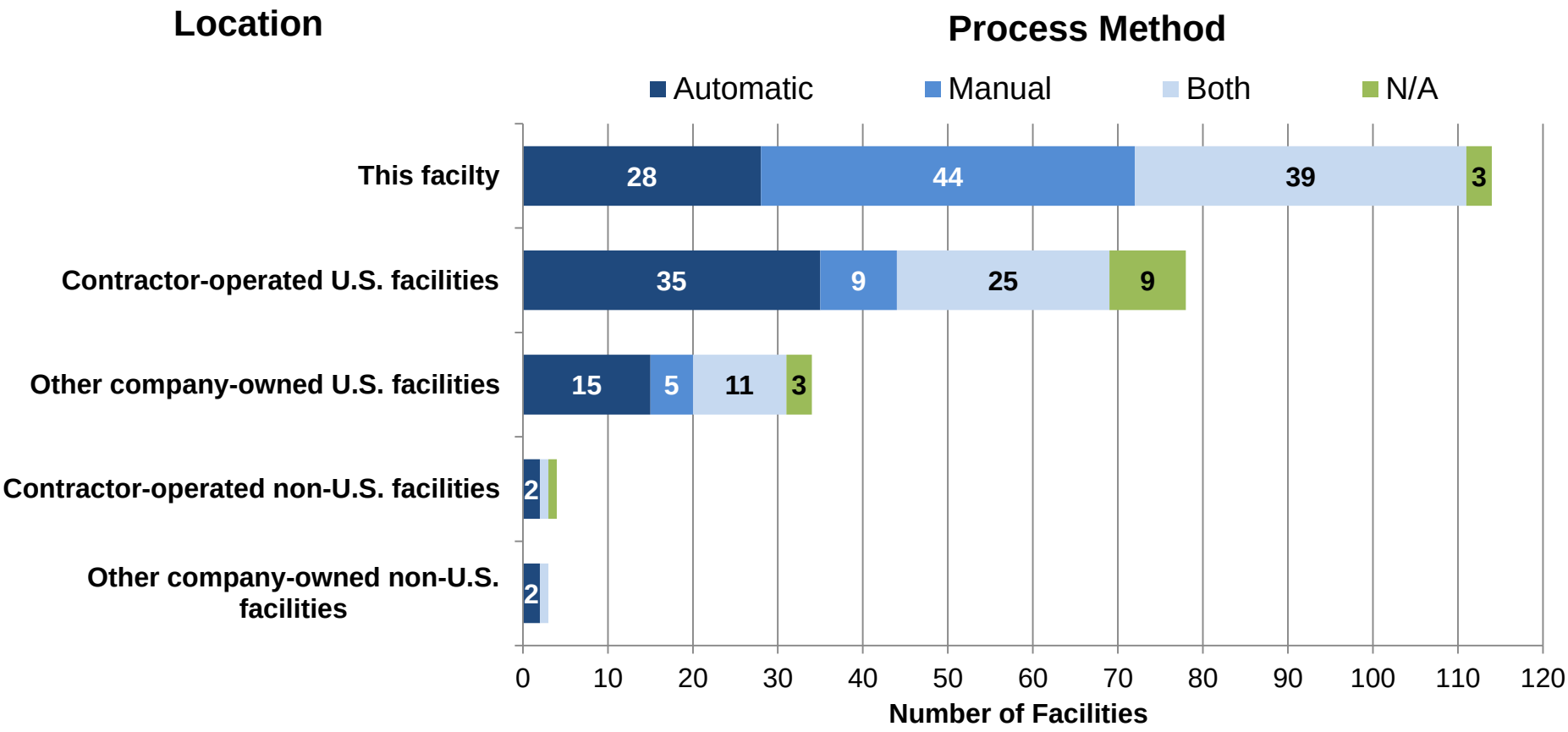
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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):



Q5b,C

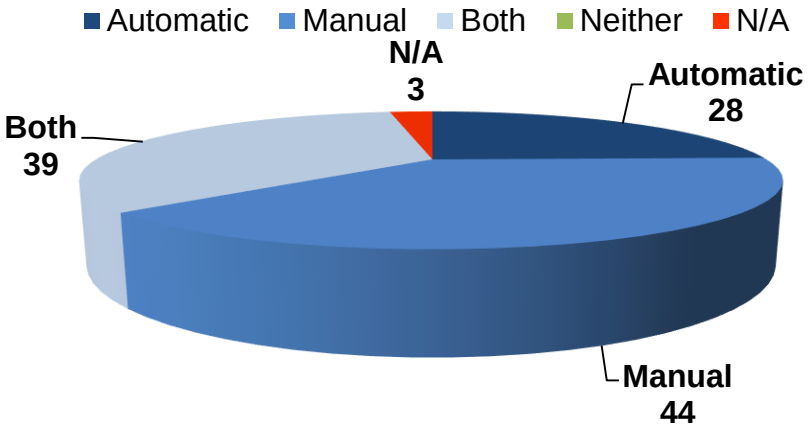
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Facility Manufacturing Capabilities

PCB Via Fill and Planarization: Locations and Process Methods

Process Methods: This Facility



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

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

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

Q5b,C

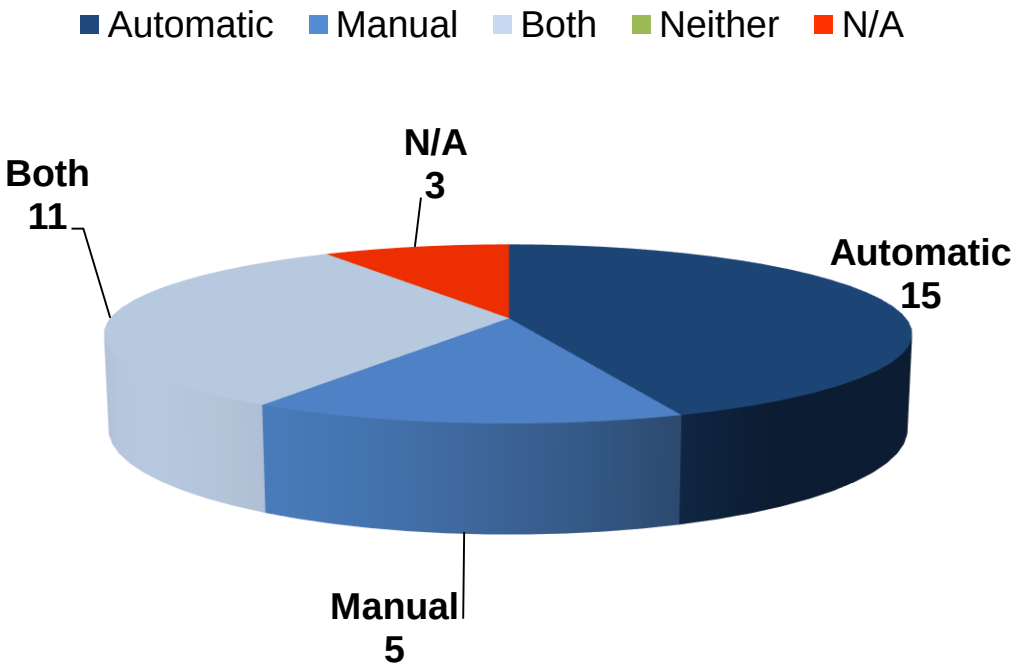
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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

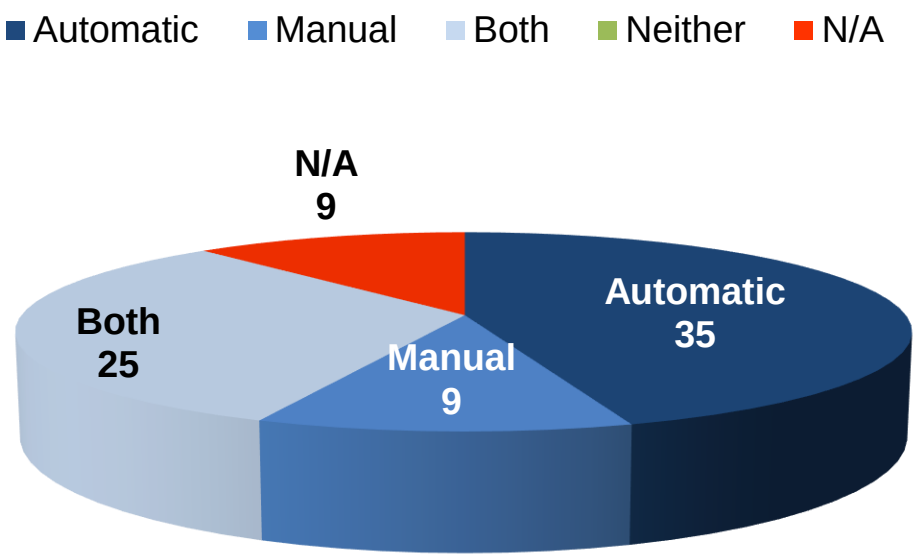
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

34 respondents

Facility Manufacturing Capabilities

PCB Via Fill and Planarization: Locations and Process Methods

Process Methods:
Contractor-operated U.S. facilities



Both: Explanations

- Both auto and manual planarizer
- Only utilized in capacity constrained situation
- Outsourced locally
- Sometimes we subcontract
- Use 3rd-party contractor for via-fill, but planarization is done in-house
- We use an outside service for large runs of conductive and non-conductive via fill

Automatic: Explanations

- California location
- Conductive via filling - can do in house, but only very small demand so some work is outsourced
- Dependent on volume and/or hole size
- Hole fill, planarization performed in-house & out-sourced
- Planarizing Machine

Q5b,C

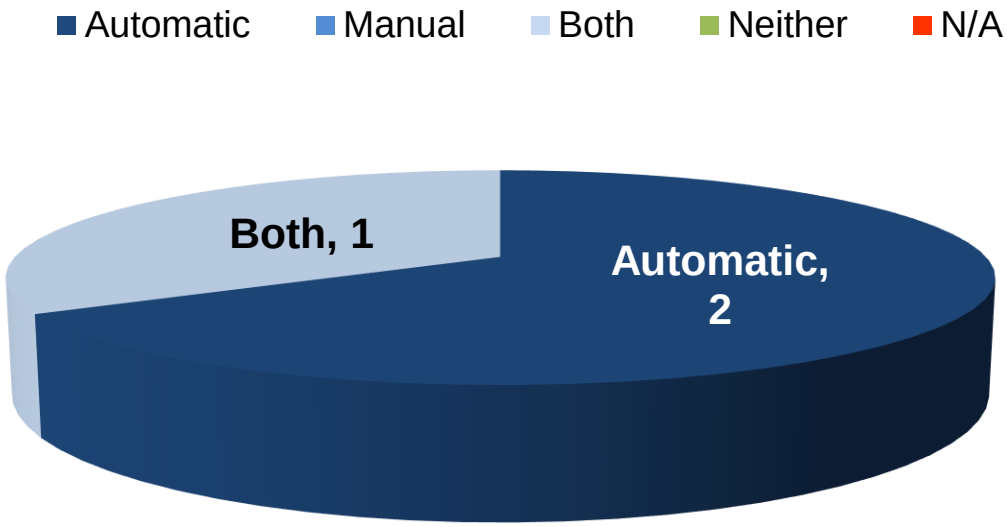
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

78 respondents

Facility Manufacturing Capabilities

PCB Via Fill and Planarization: Locations and Process Methods

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



Both: Explanations

- Hand screened and planarized using automatic planarizer

Automatic: Explanations

- Commercial customer only

Q5b,C

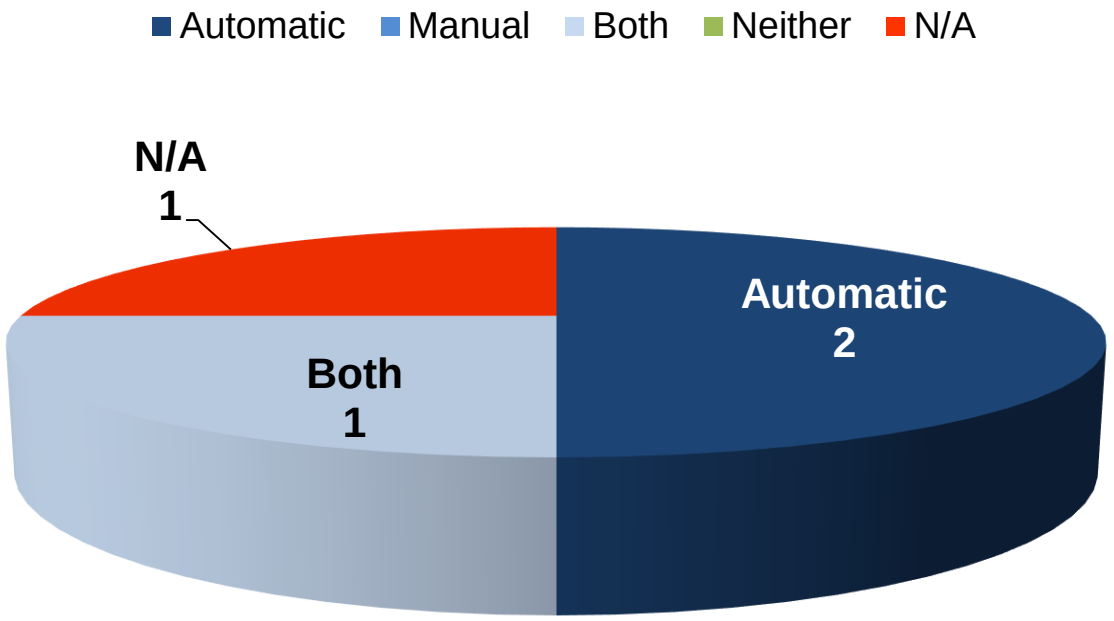
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

3 respondents

Facility Manufacturing Capabilities

PCB Via Fill and Planarization: Locations and Process Methods

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



Automatic: Explanations

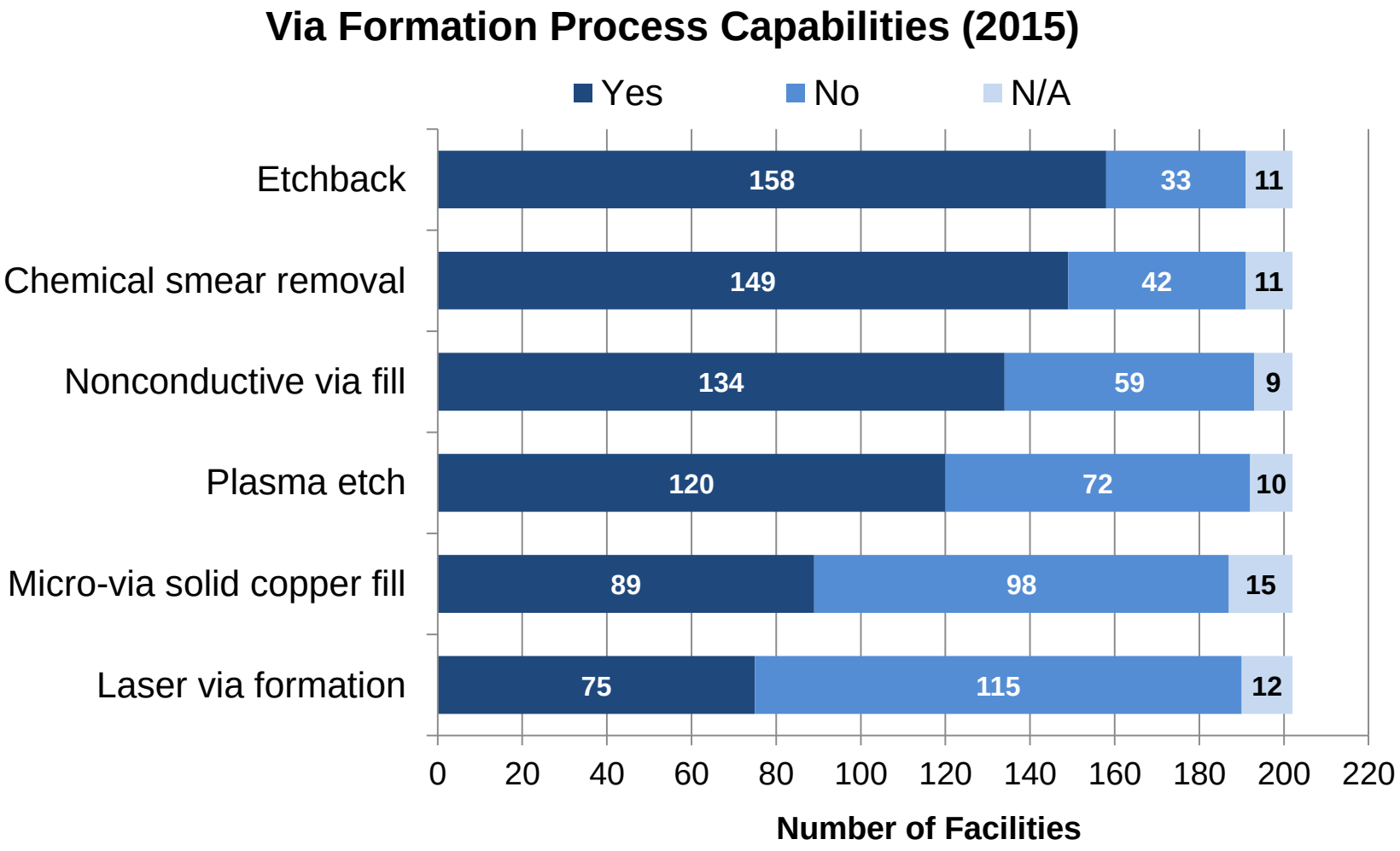
- Planarizing Machine

Q5b,C

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

4 respondents

Facility Manufacturing Capabilities
Via Structures



Q5b,D

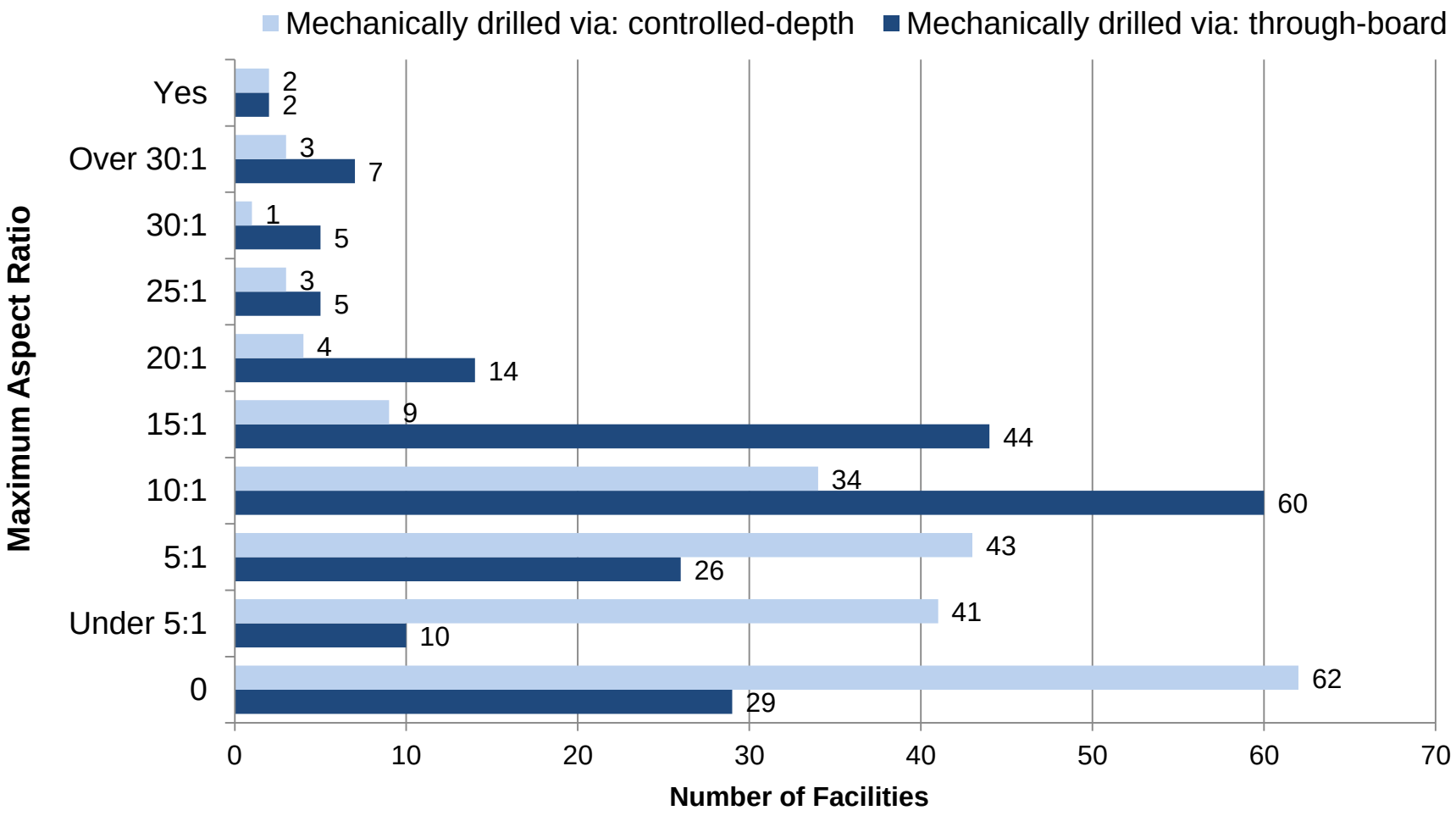
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Facility Manufacturing Capabilities

Mechanically Drilled Vias

Via Structure Drilling Process Capabilities (2015)



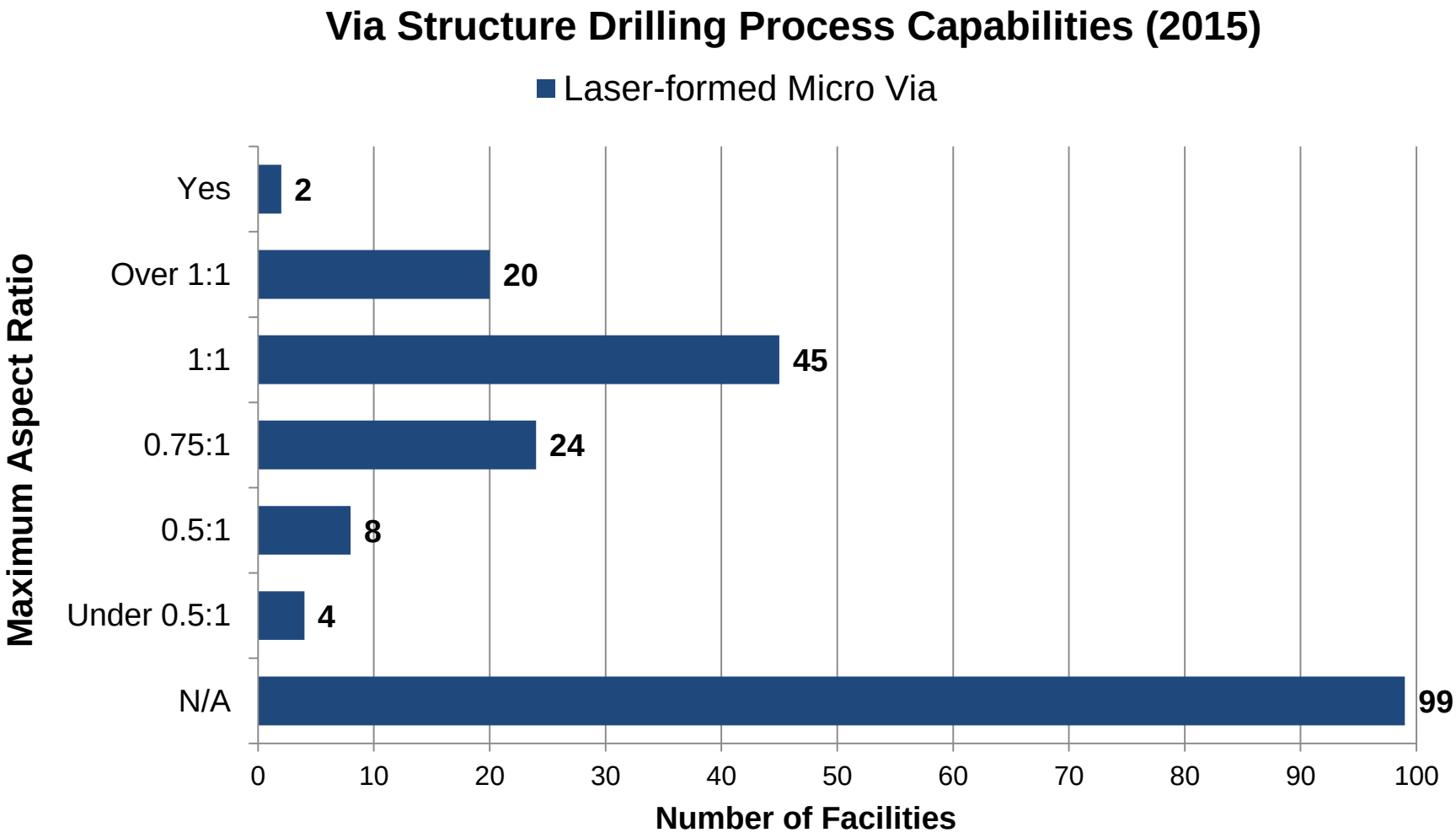
Q5b,D

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

Laser-formed Micro Vias

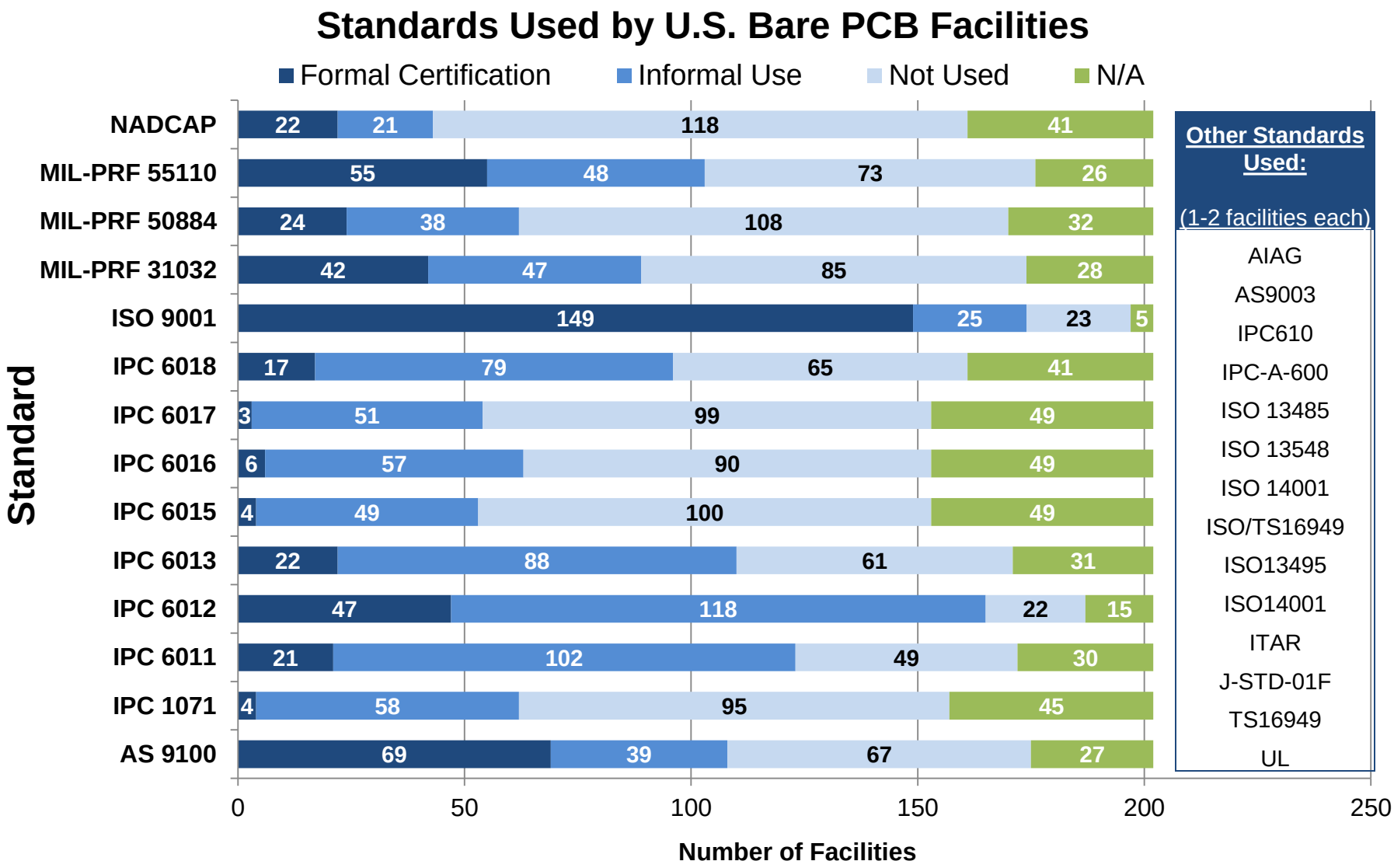


Q5b,D

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

202 respondents

Facility Manufacturing Standards (2015)



Q5c,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 Standards – MIL Certification

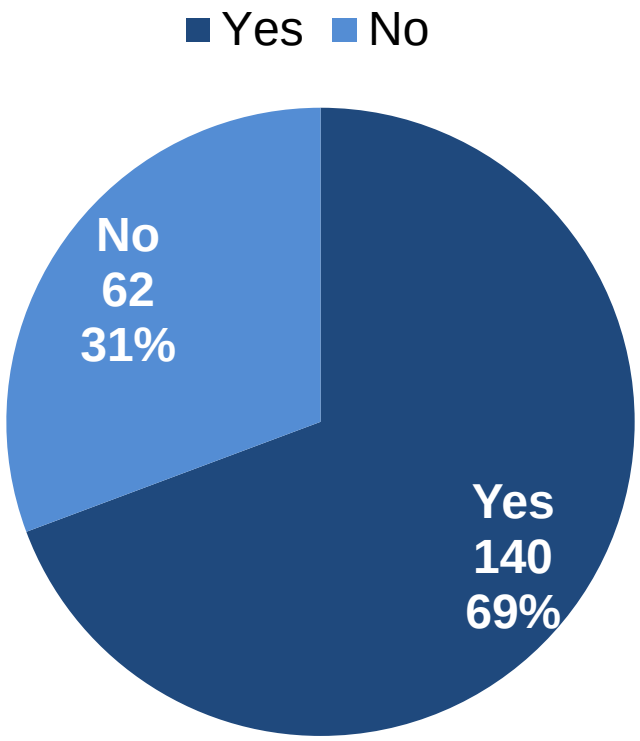
- Only 31% of U.S. PCB manufacturing facilities hold an official MIL certification.
  - MIL-PRF 31032: 42 total facilities (only 14 of 146 small)
  - MIL-PRF 50884: 24 total facilities (only 11 of 146 small)
  - MIL-PRF 55110: 55 total facilities (only 28 of 146 small)

- 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
Use of Active Technical Review Boards (2015)

Does This Facility Have an Active Technical Review Board



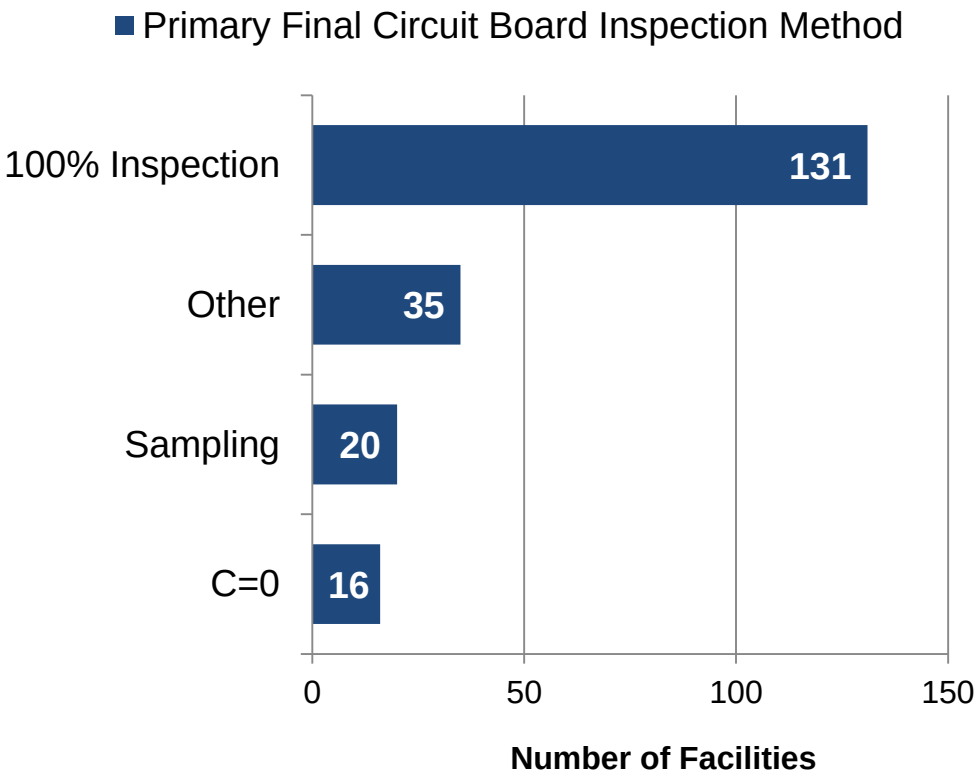
Q5c,B

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

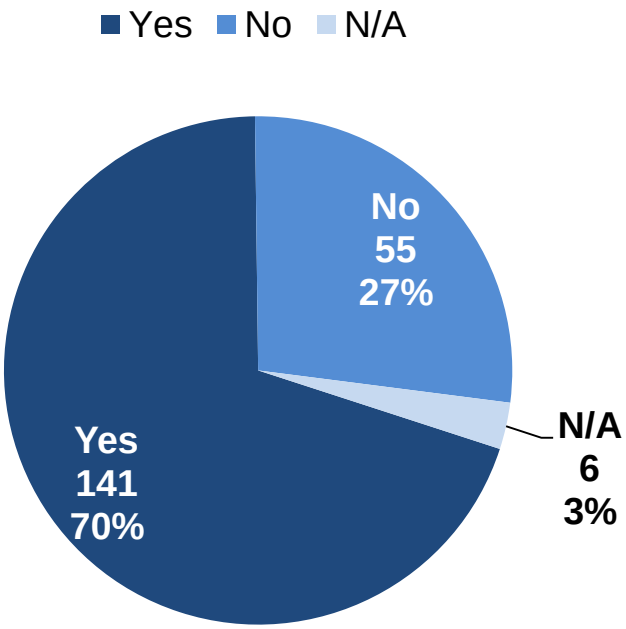
202 respondents

Facility Manufacturing Standards
Inspection Methods and Capabilities (2015)

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



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



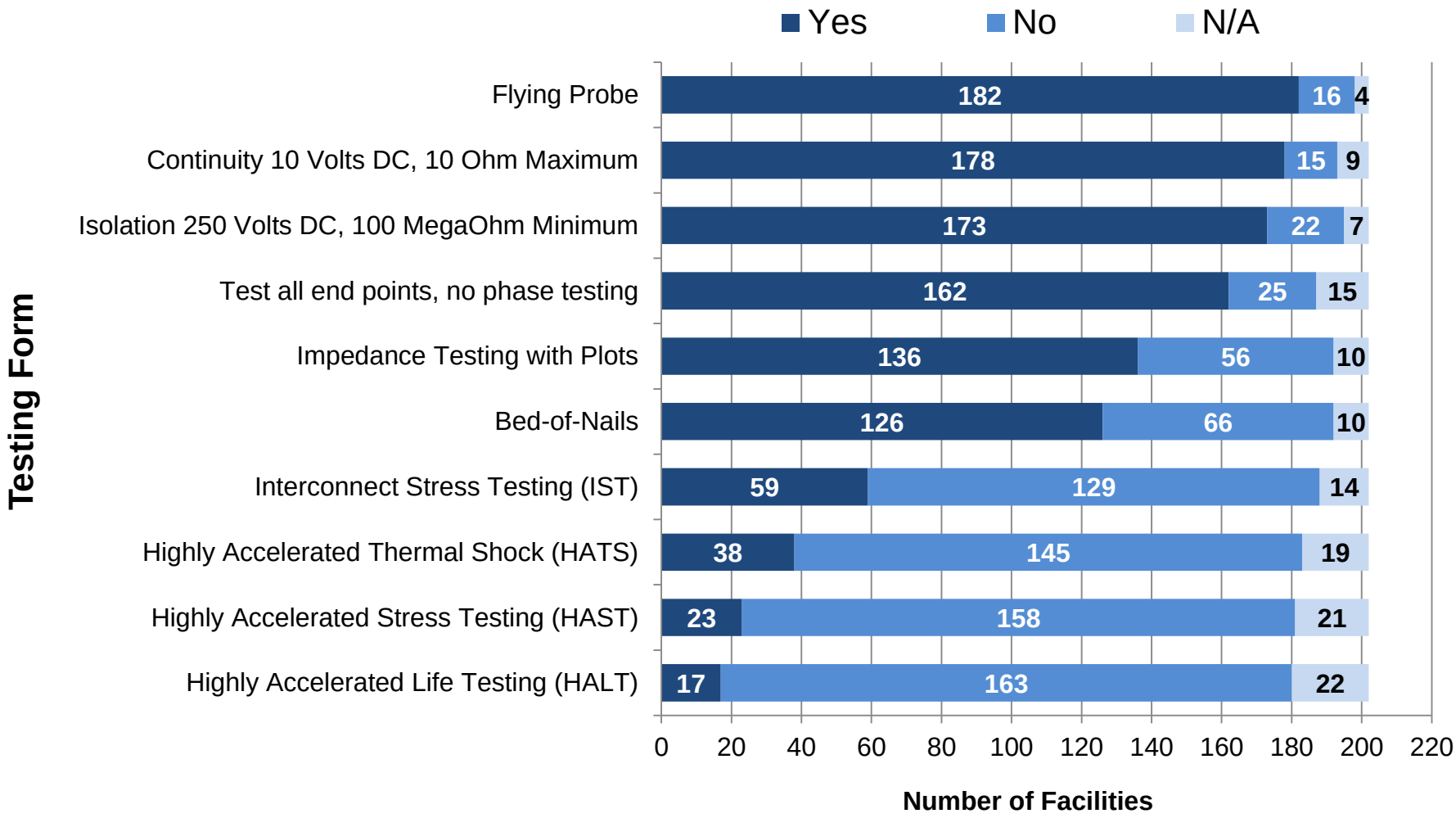
Q5c,C

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

202 respondents

Facility Manufacturing Standards

Forms of Testing Used for Bare PCB Performance (2015)



Q5c,D

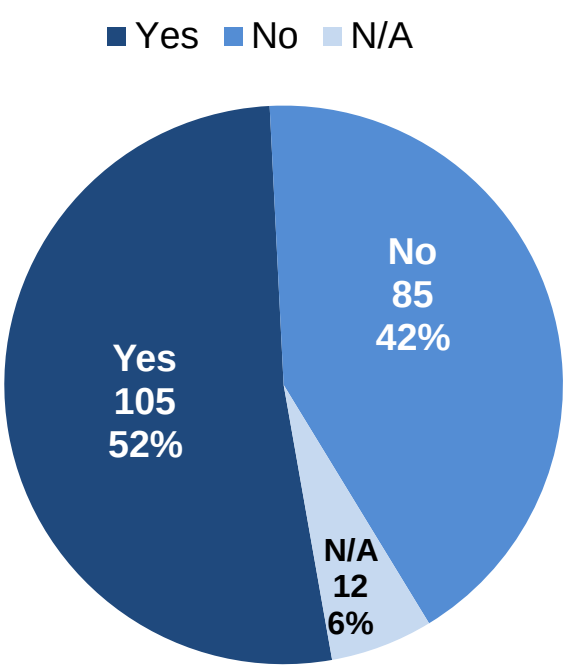
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

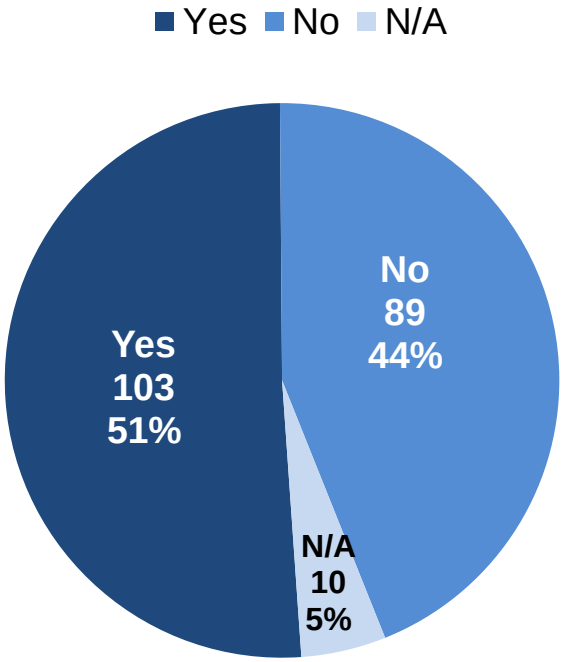
Facility Manufacturing Standards - Software

Statistical Process Control and Material Requirements Planning (2015)

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



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



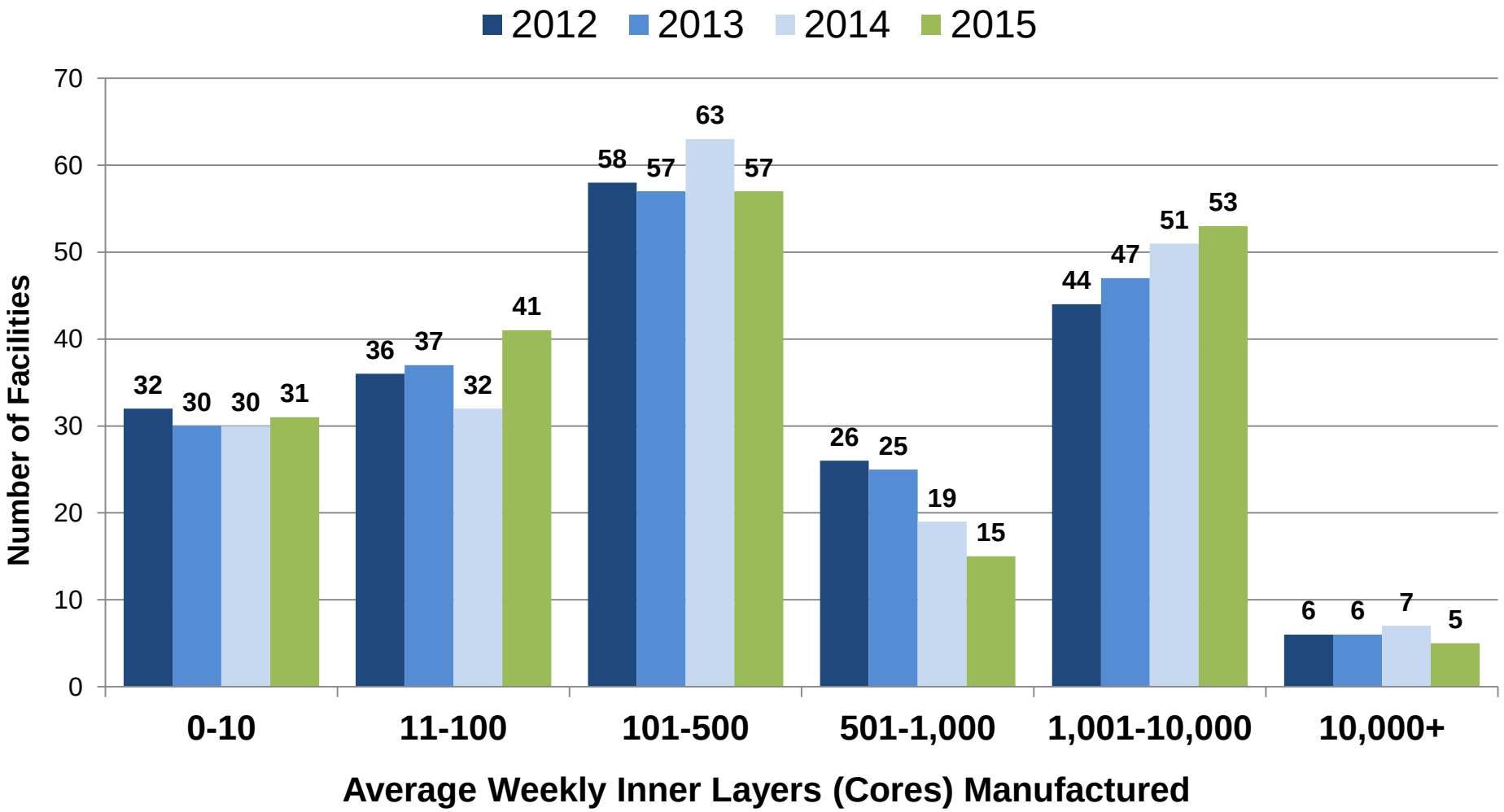
Q5c,E

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

202 respondents

Facility Manufacturing Production and Capacity

Average Weekly Inner Layers (Cores) Manufactured (2012-2015)



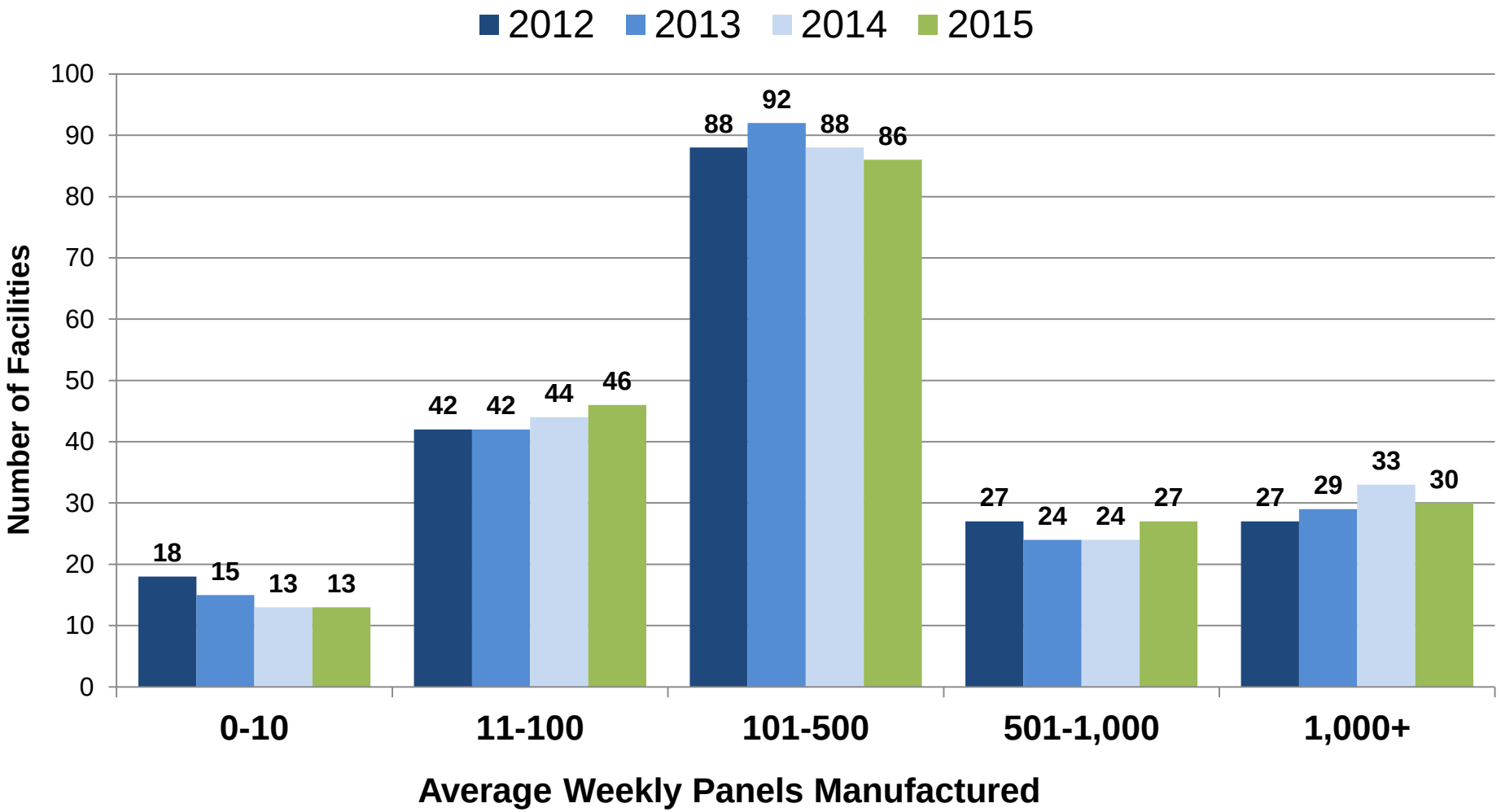
Q5d,A

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

Average Weekly Panels Manufactured (2012-2015)



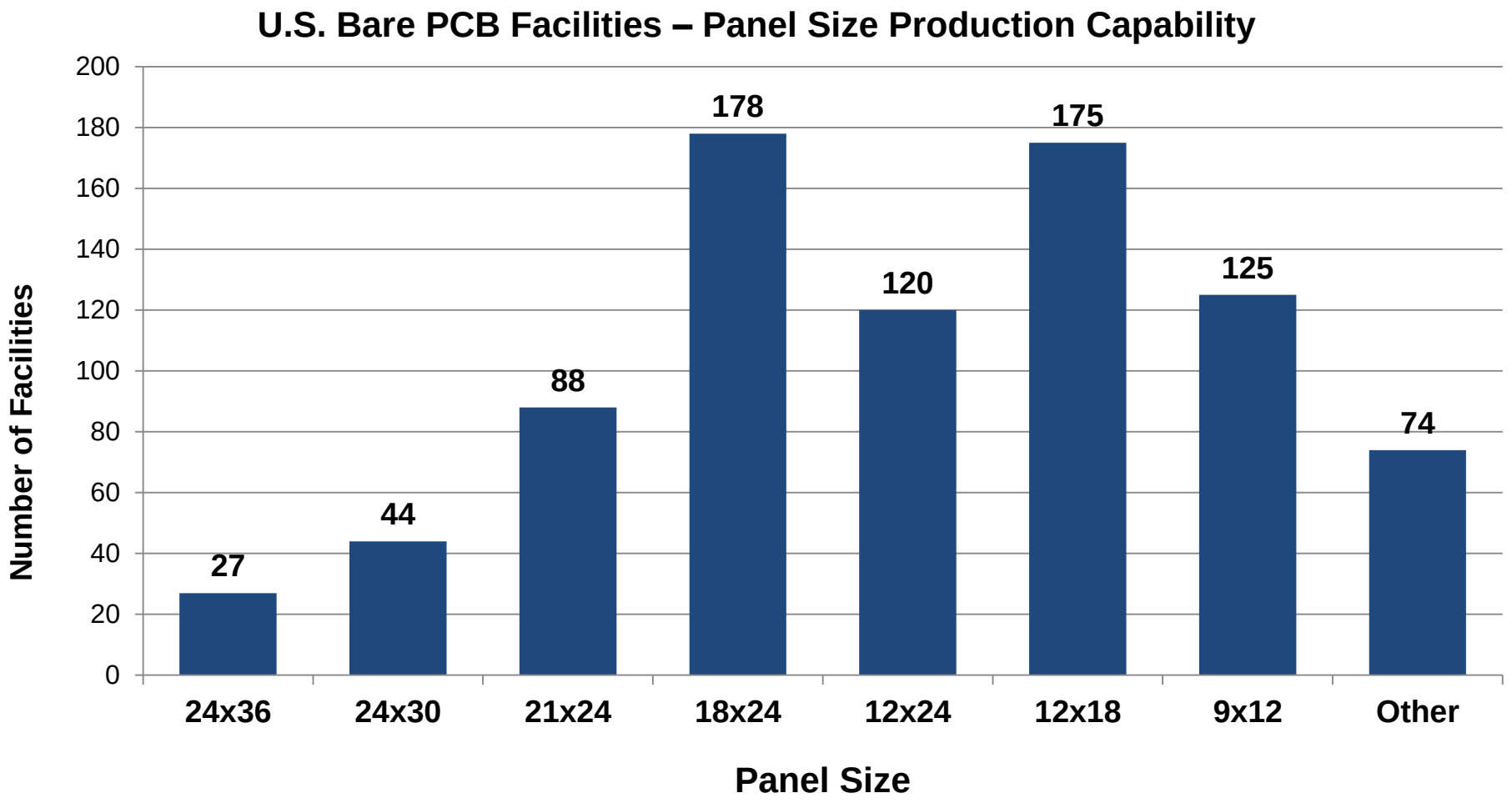
Q5d,A

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

Bare PCB Panels: Range of Sizes (2015)



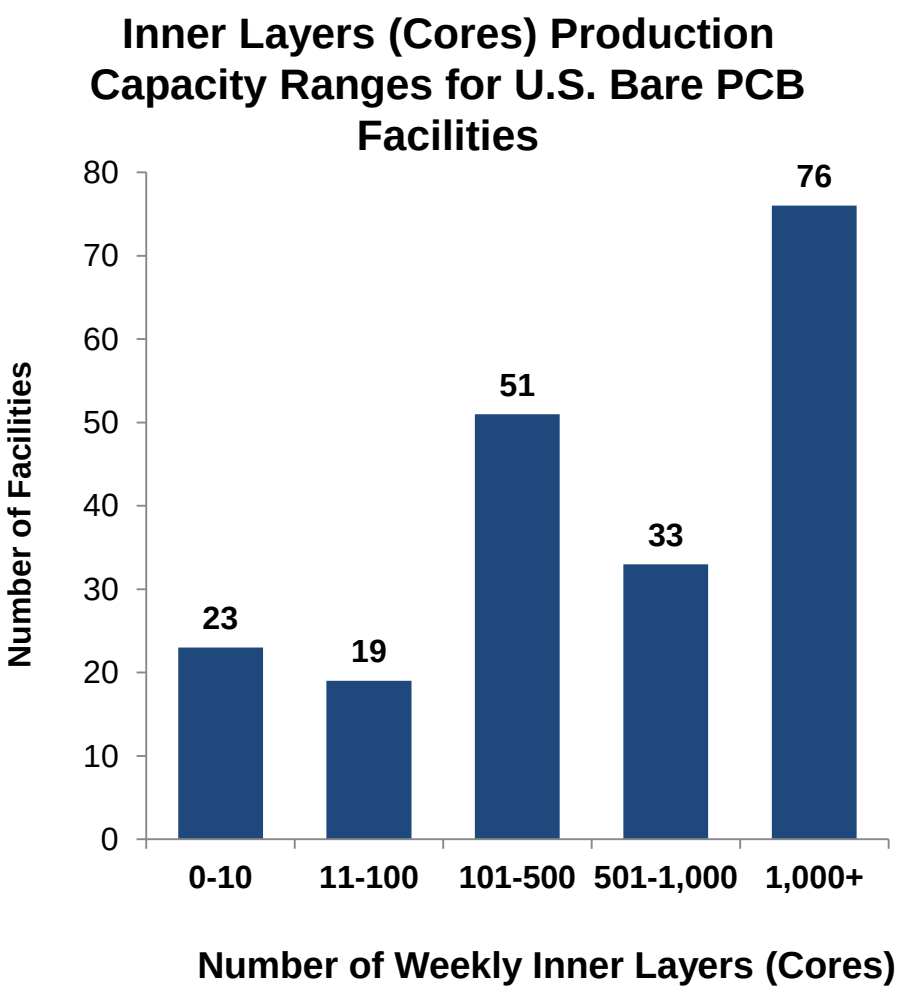
Q5d,B

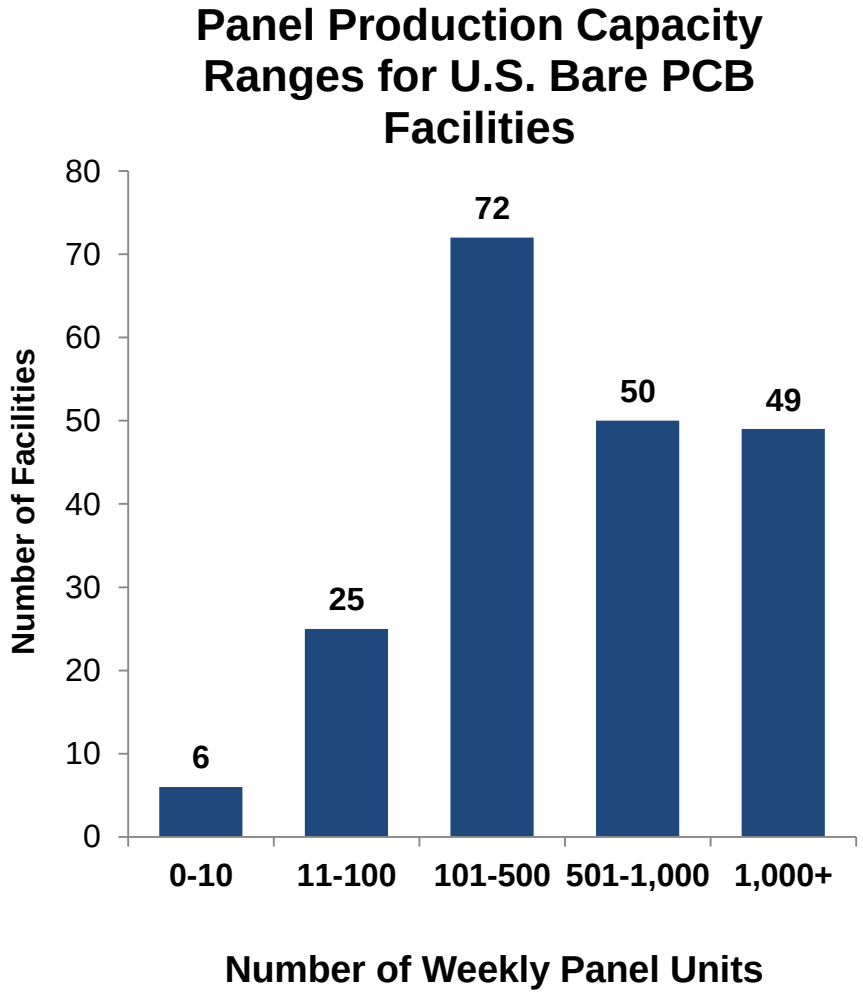
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Facility Manufacturing Production and Capacity

Rated Weekly Inner Layer and Panel Facility Capacity (2015)





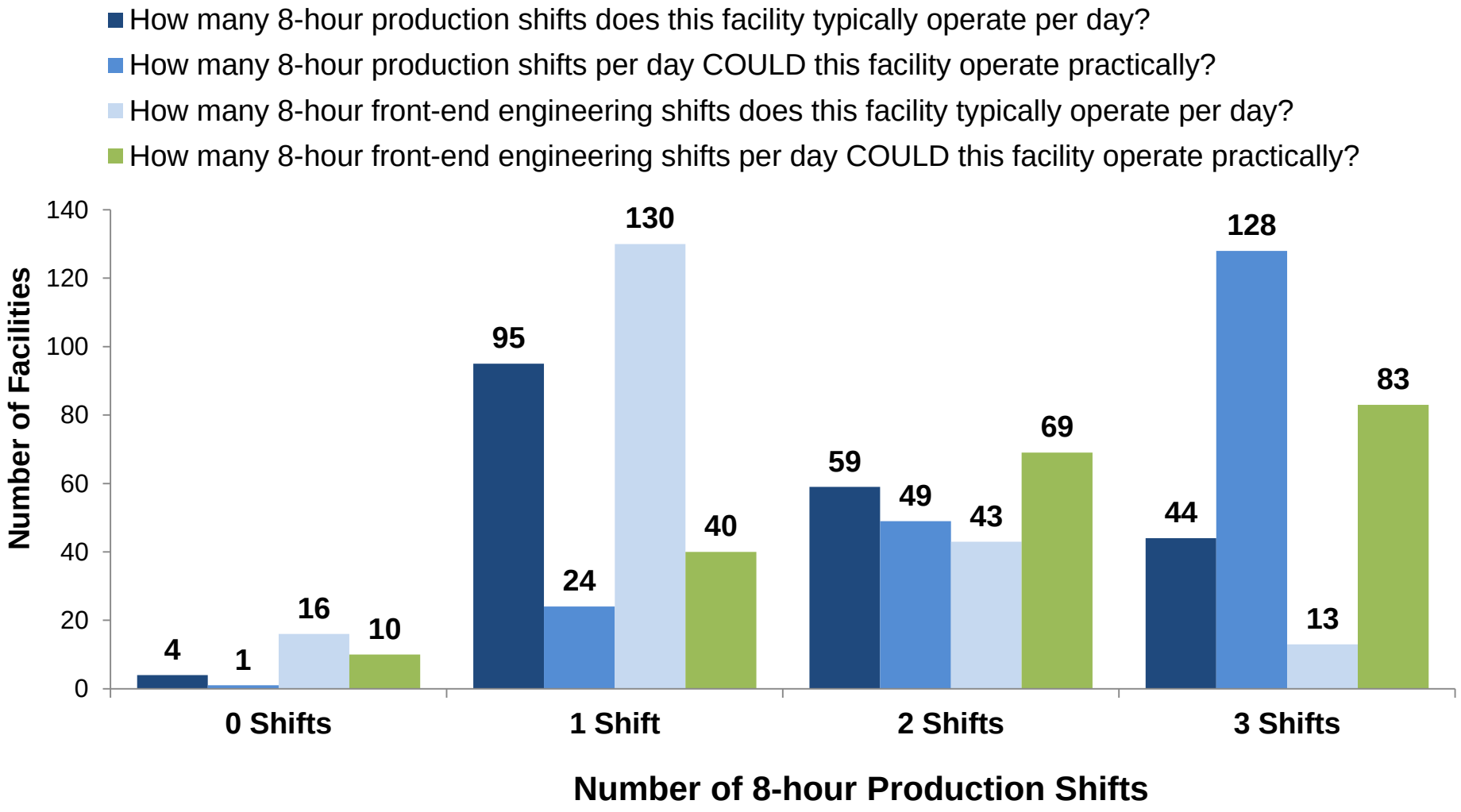
Q5d,C

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

202 respondents

Facility Manufacturing Production and Capacity

Production Shifts Per Day (2015)



Q5d,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 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"

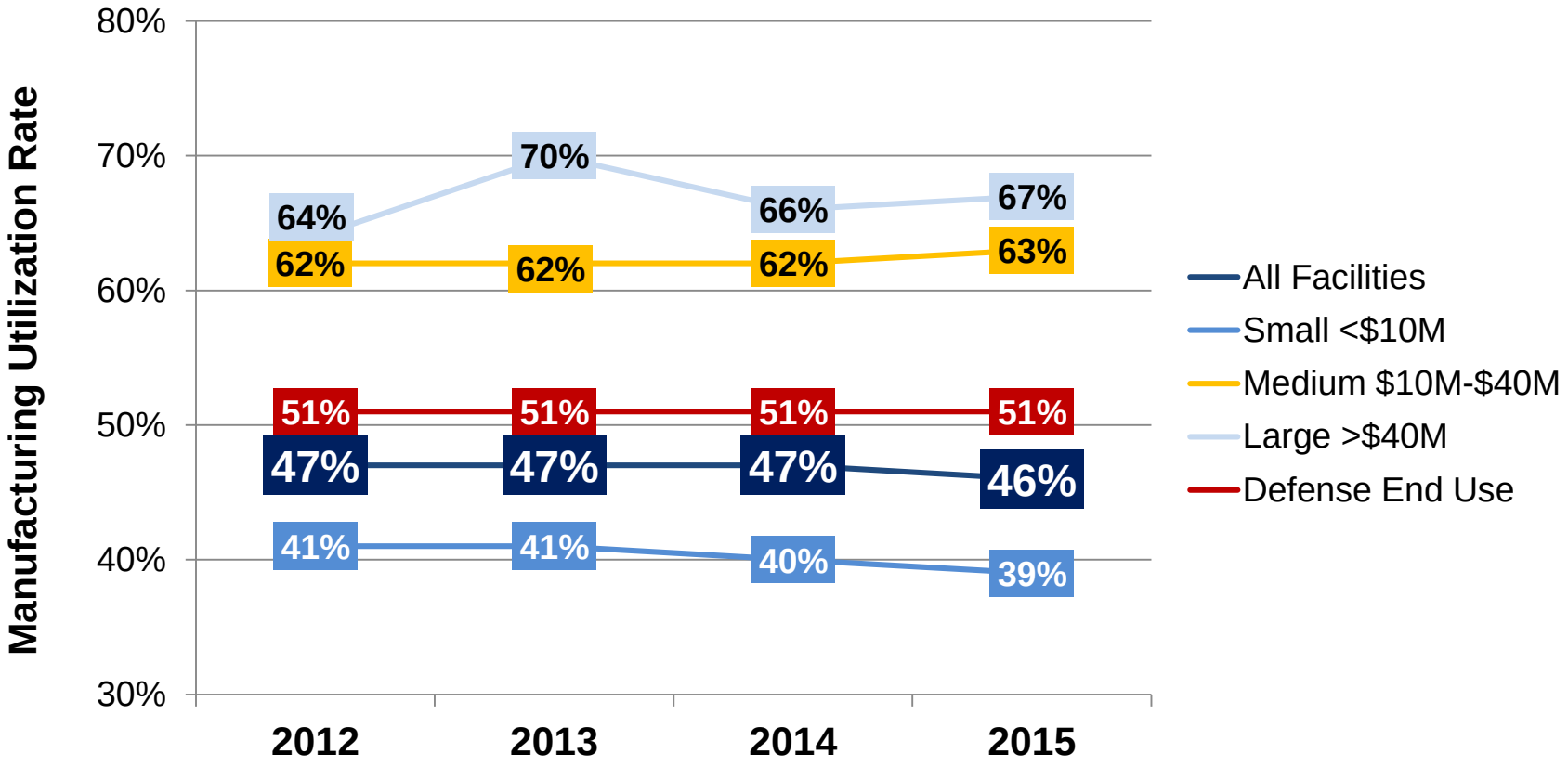
Q5d,D

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

202 respondents

Facility Manufacturing 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.**

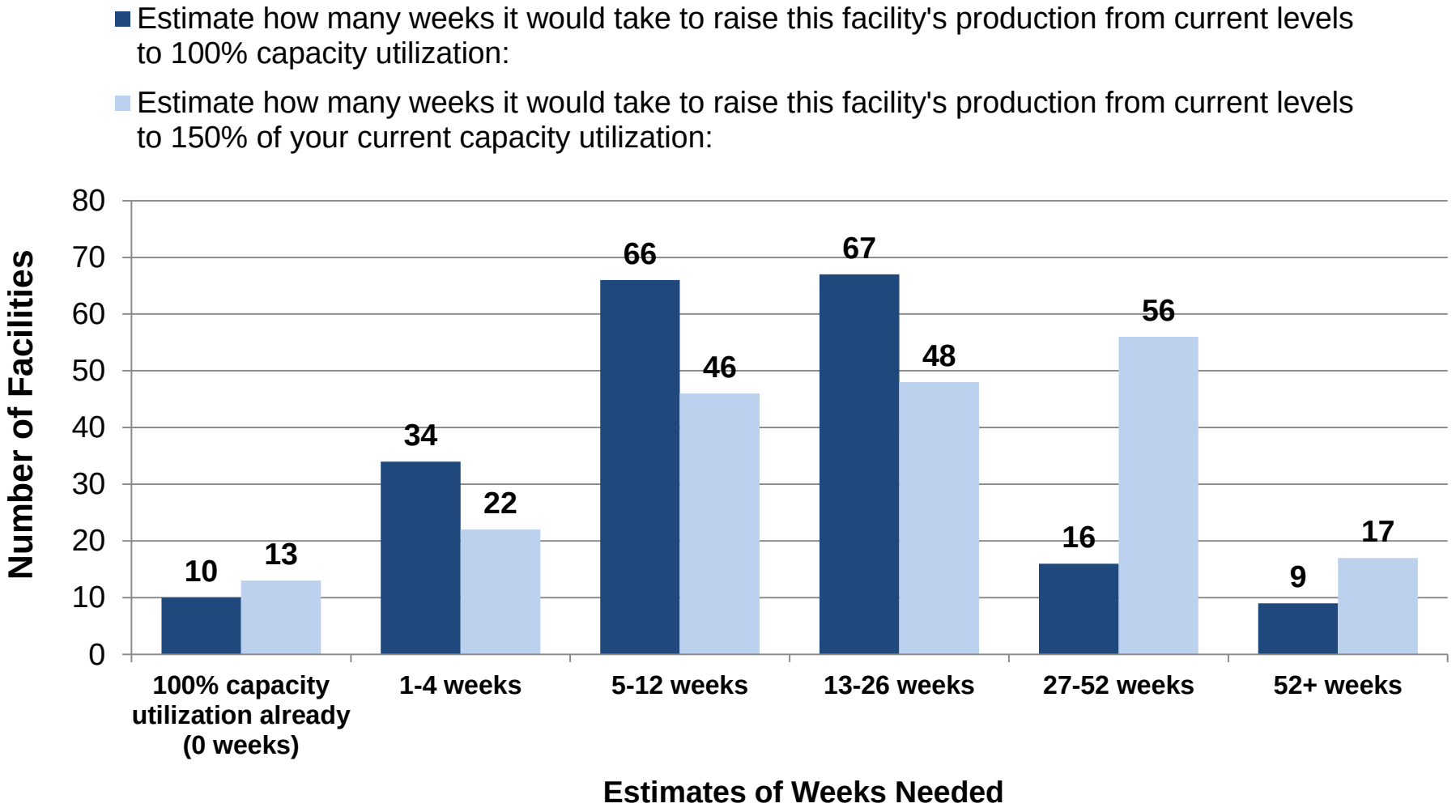
Q5d, E

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

Respondents: 202

Facility Manufacturing Production and Capacity

Raising Production Output From Current Levels (2015)



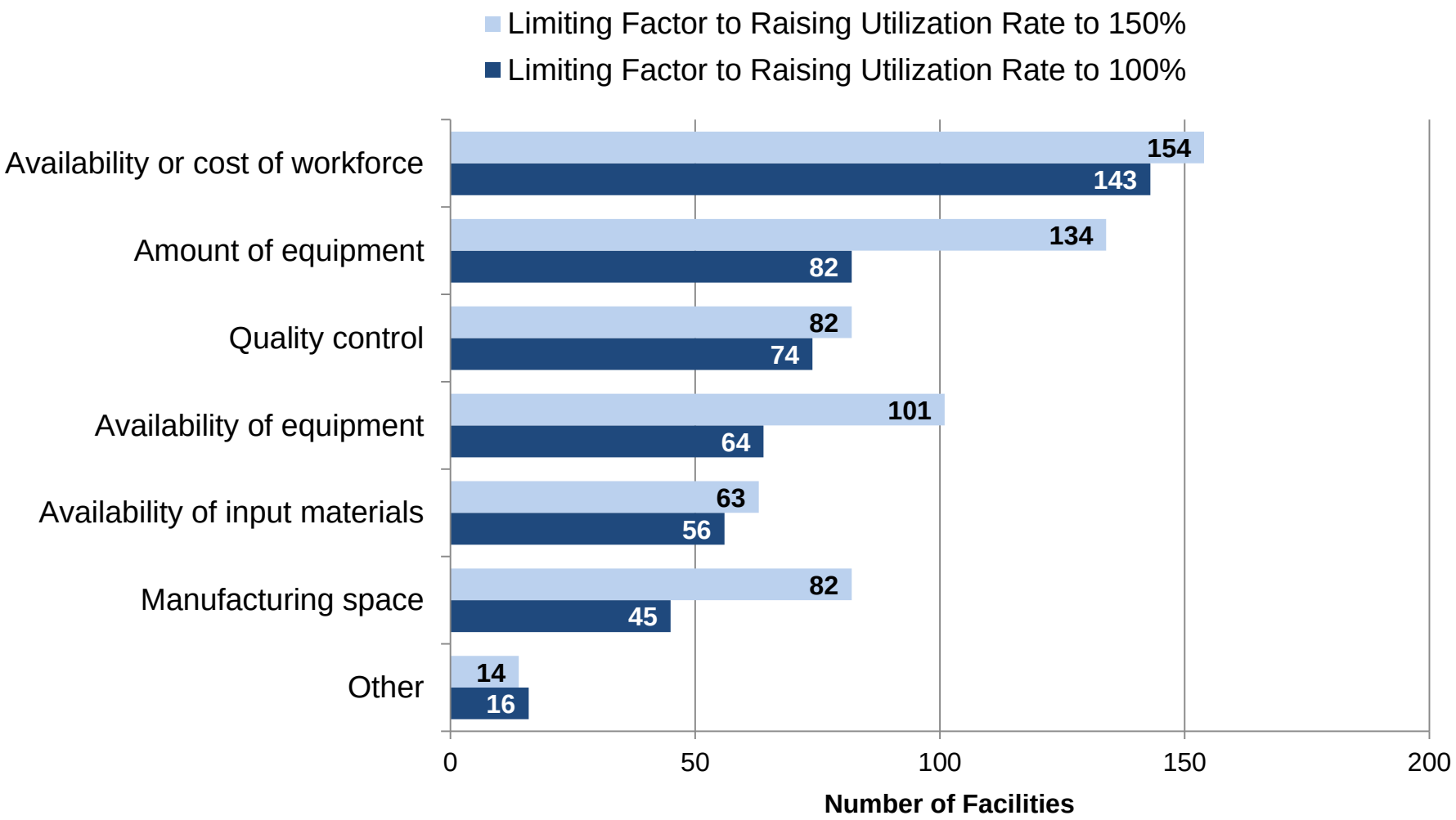
Q5d,F

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

Limiting Factors for Surge Capability (2015)



Q5d,G

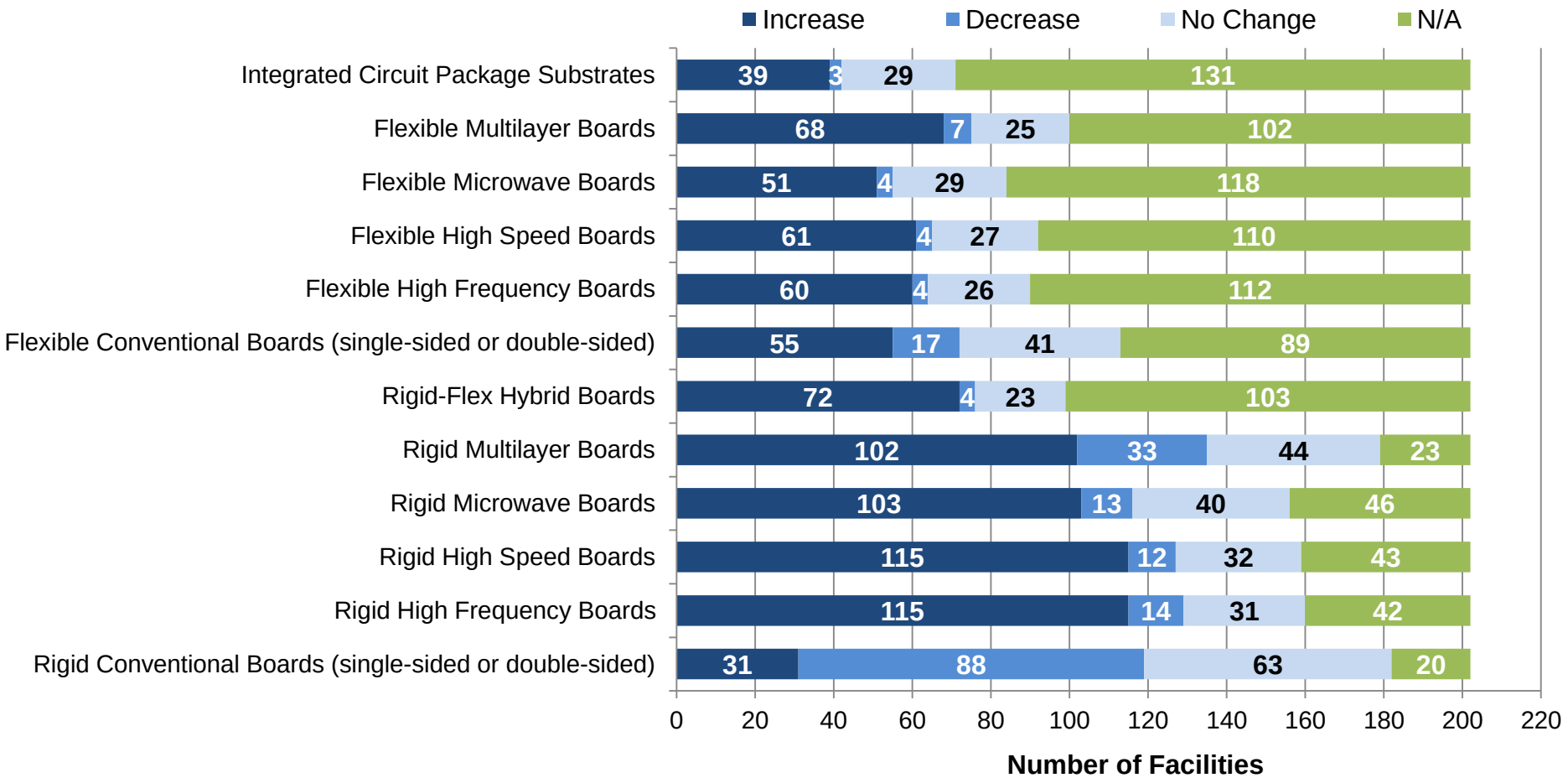
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Facility Manufacturing Production and Capacity

Anticipated Changes in 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?



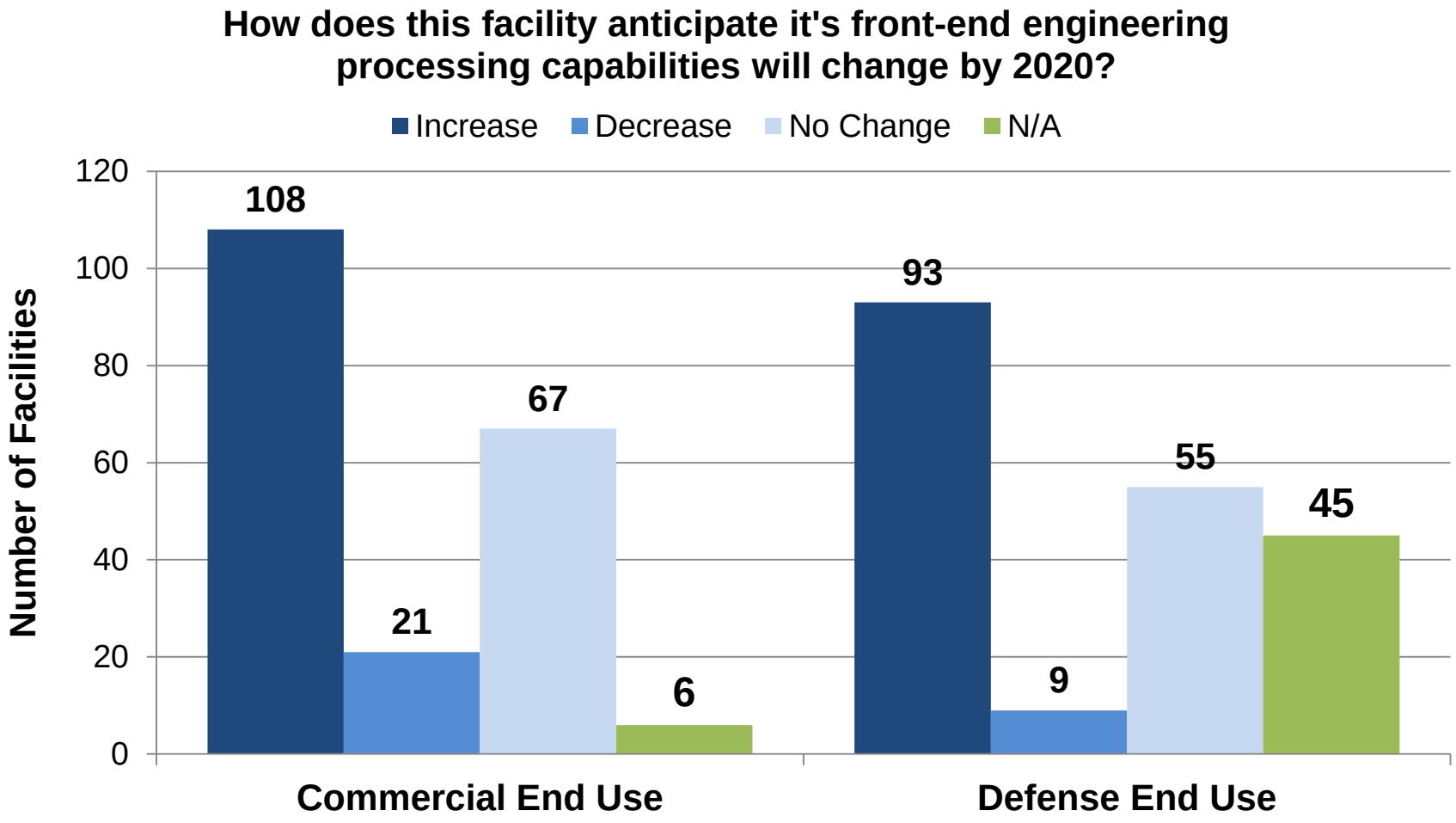
Q5e,A

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



Q5e,B

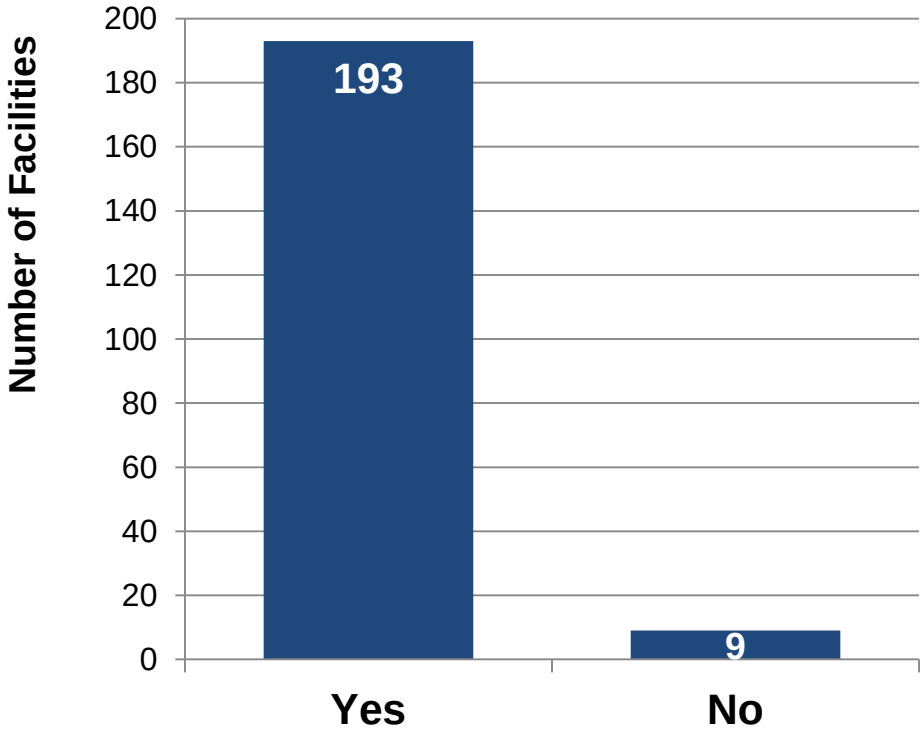
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

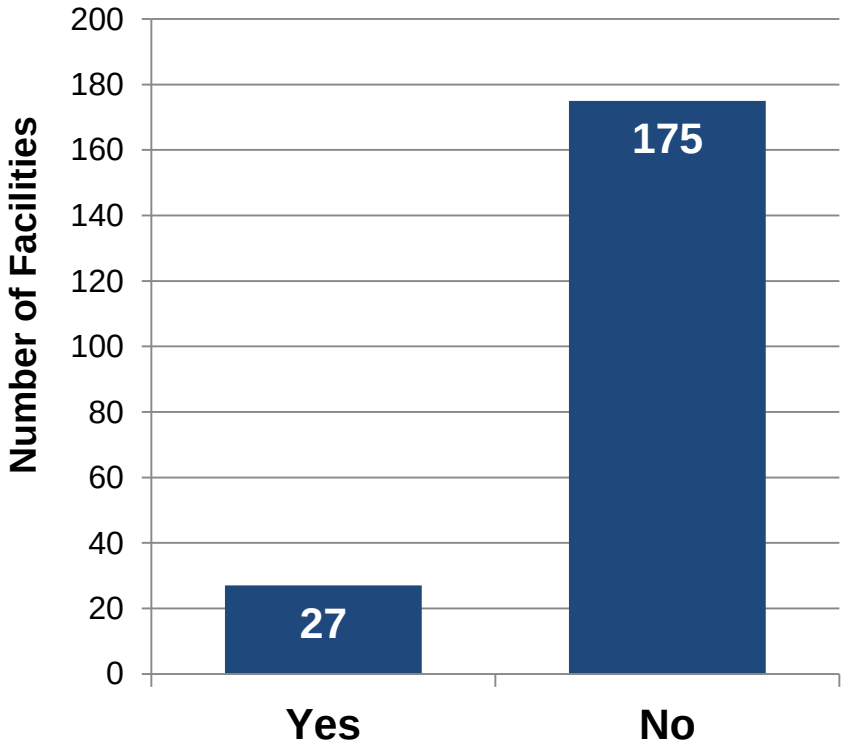
Facility Manufacturing Production and Capacity

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?



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?



Q5e,C1/C2

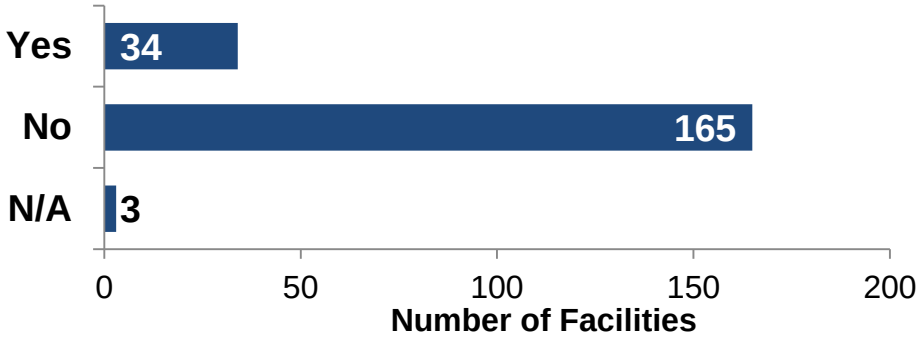
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

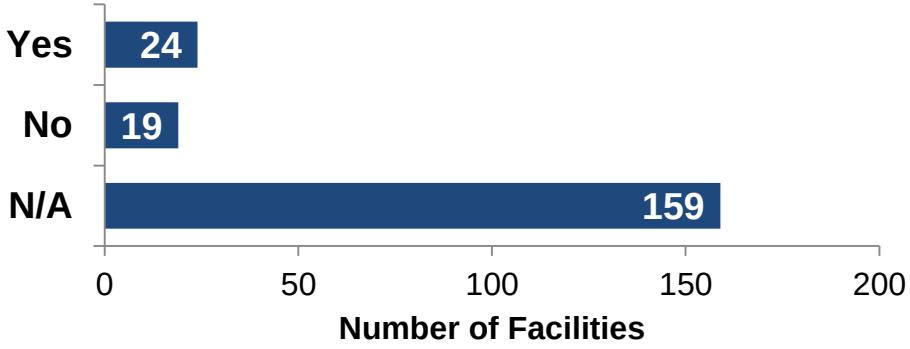
Facility Manufacturing Production and Capacity

Front-end Bare PCB Engineering: Outsource (2015)

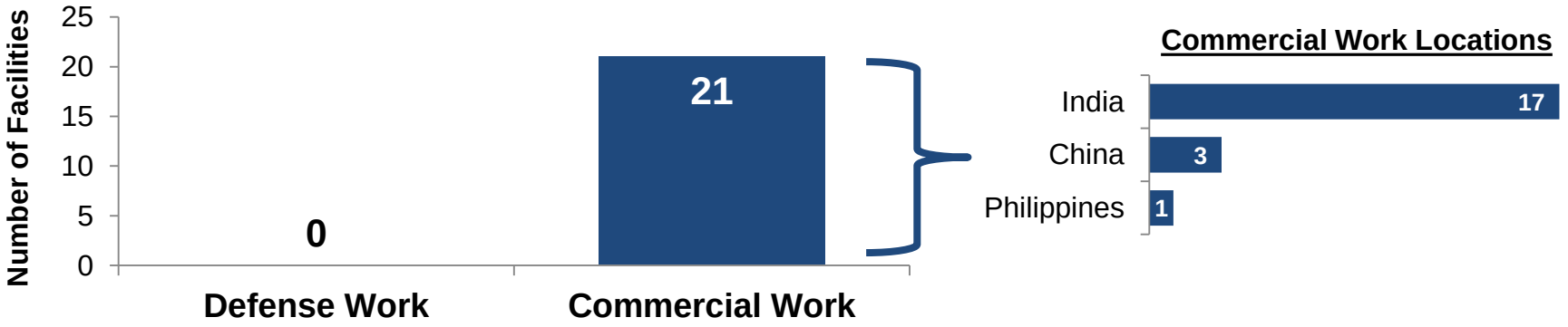
Does this facility outsource any front-end engineering for bare circuit board products manufactured at this facility?



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:



Q5e,C3

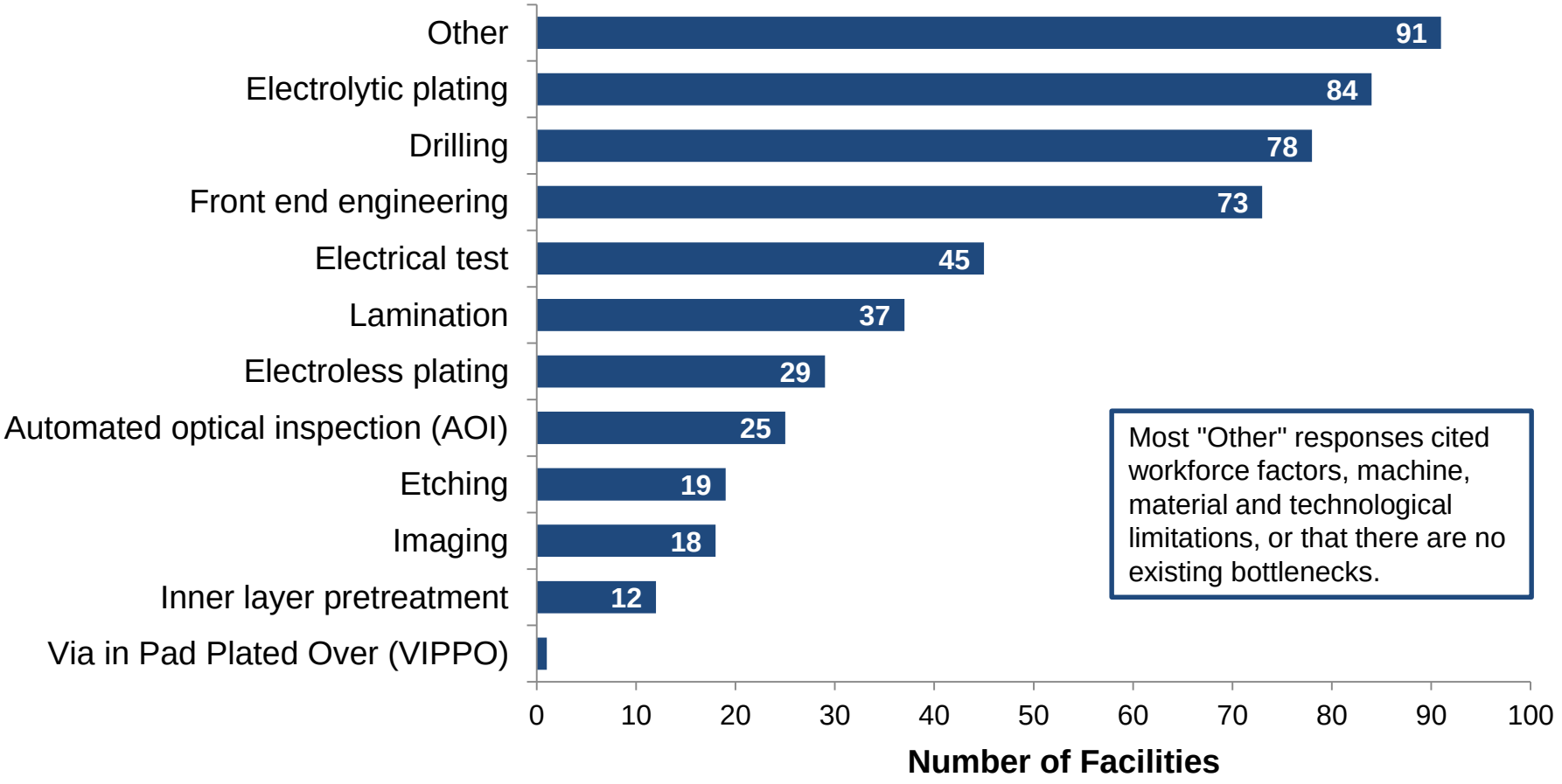
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Facility Manufacturing Production and Capacity

Primary Factors Causing Production Bottlenecks (2015)

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



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

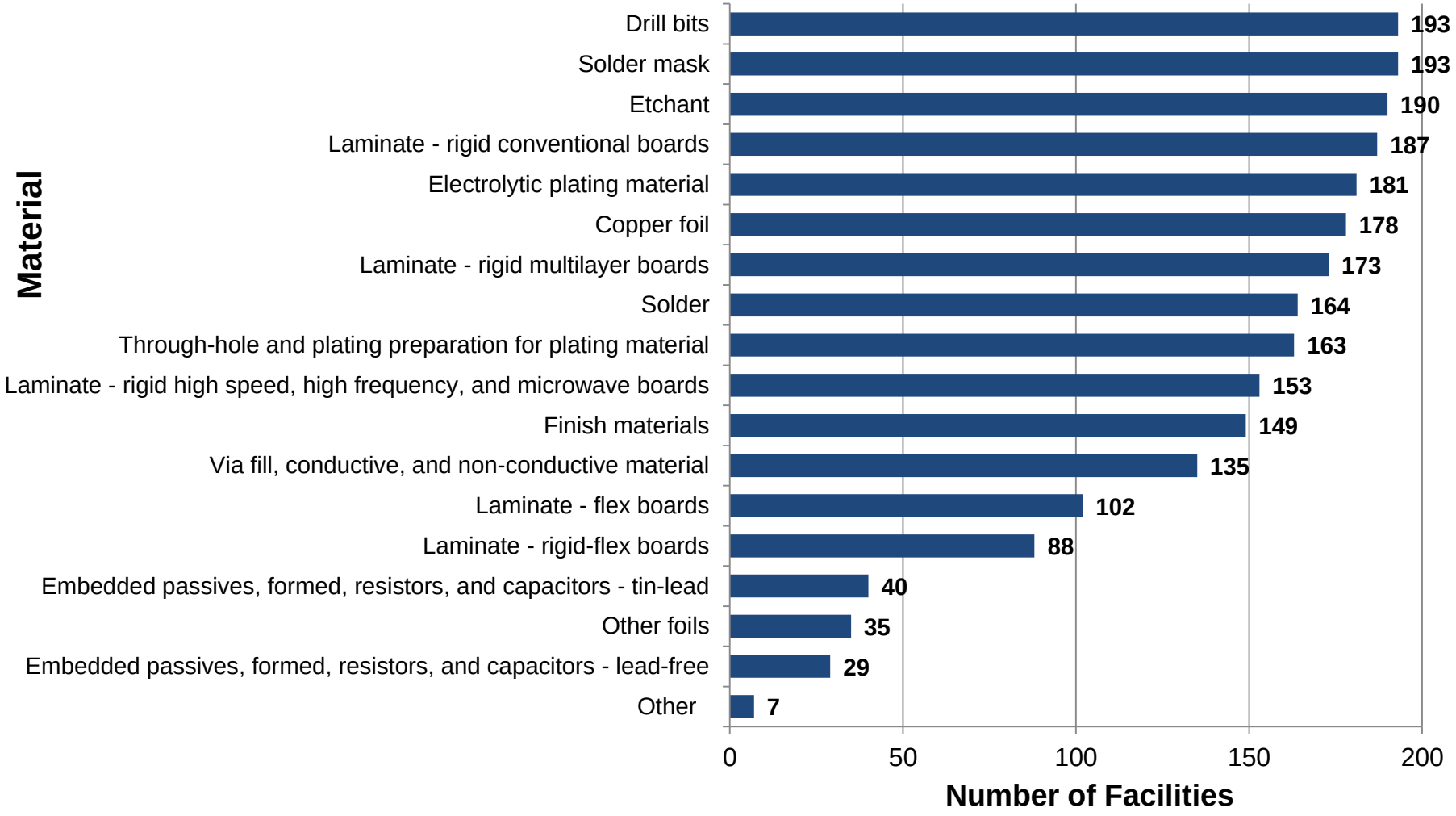
- Some DoD oversight and assessment of supply-chain capabilities is needed. Other USG agencies as well as industry needs to participate in this effort.

- **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.

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

Materials - Bare PCB Material Sourcing

Facilities Reporting One or More Suppliers (2015)



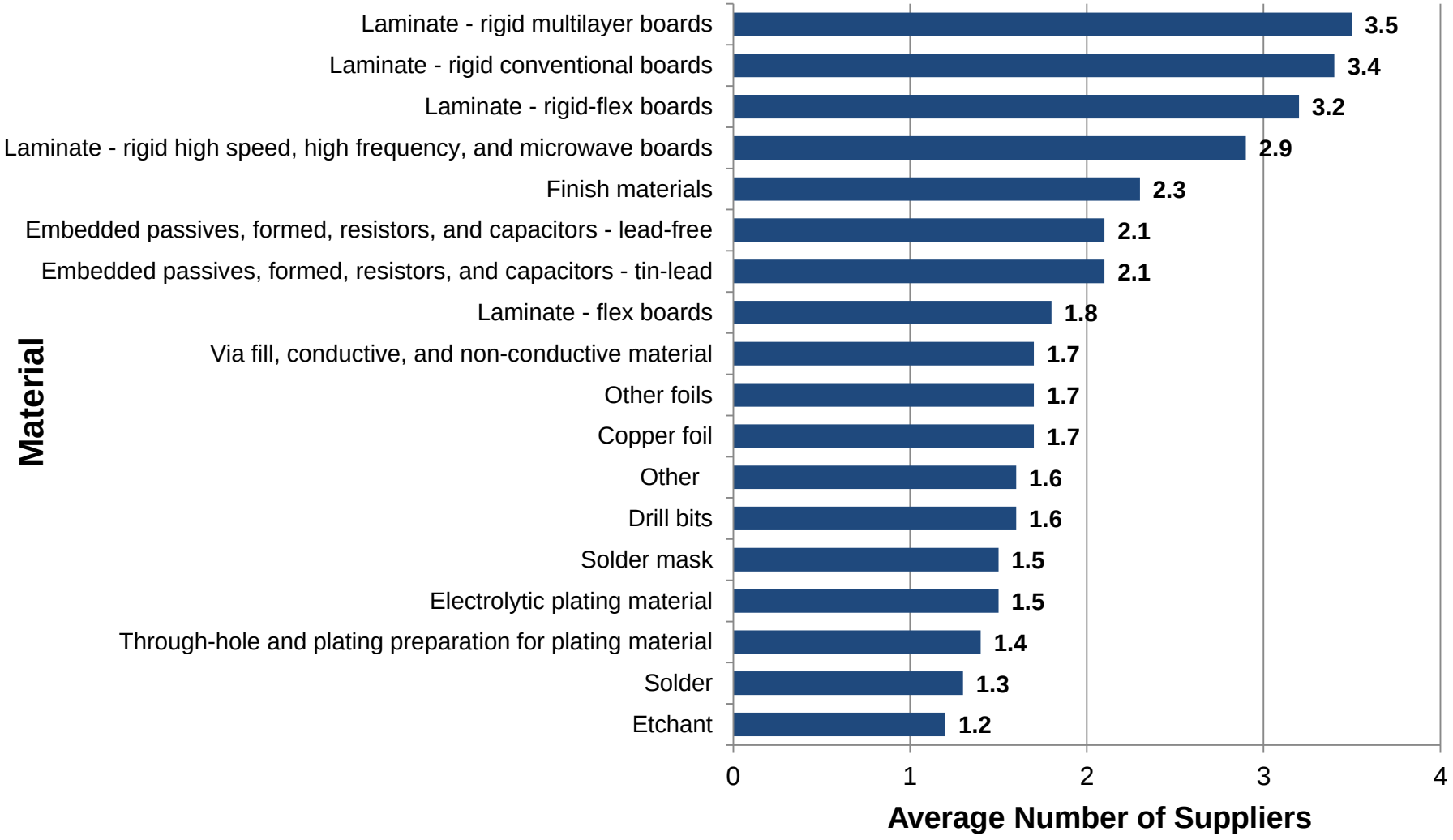
Q6a,A

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)



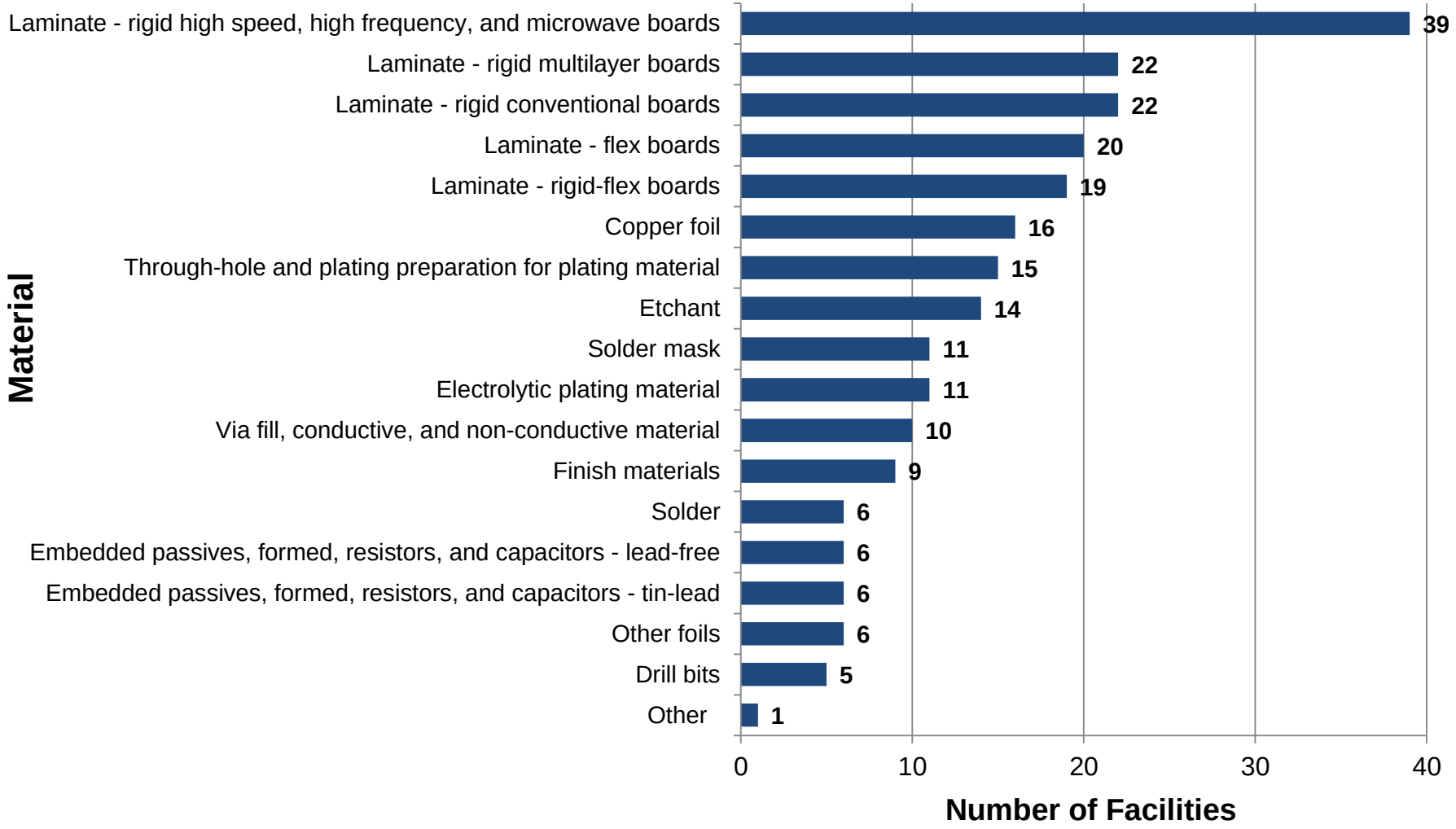
Q6a,A

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)



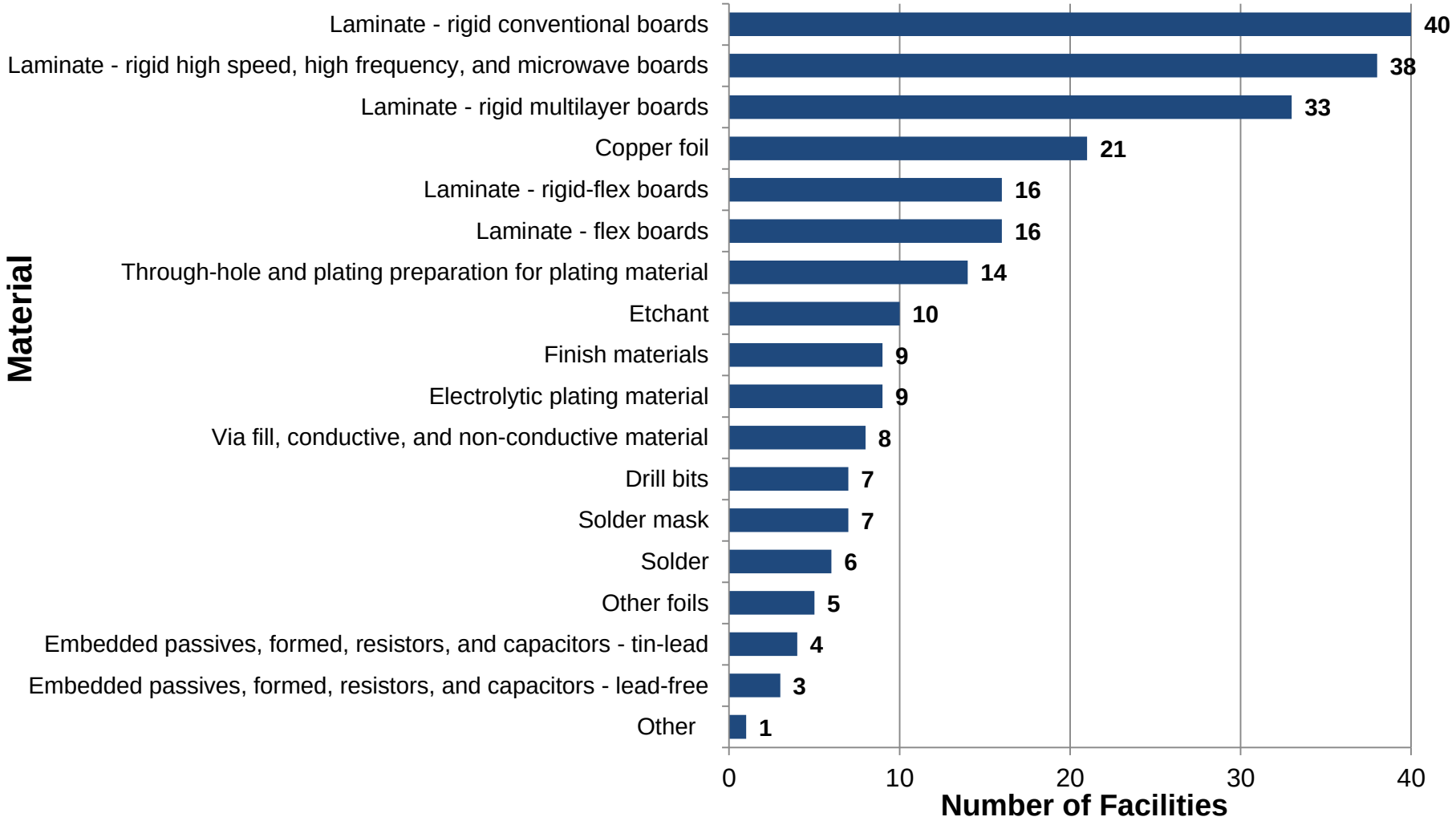
Q6a,A

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

202 respondents

Materials - Supply Chain Disruptions Since 2012

Facilities That Experienced Supply Chain Disruptions (2012 to 2015)



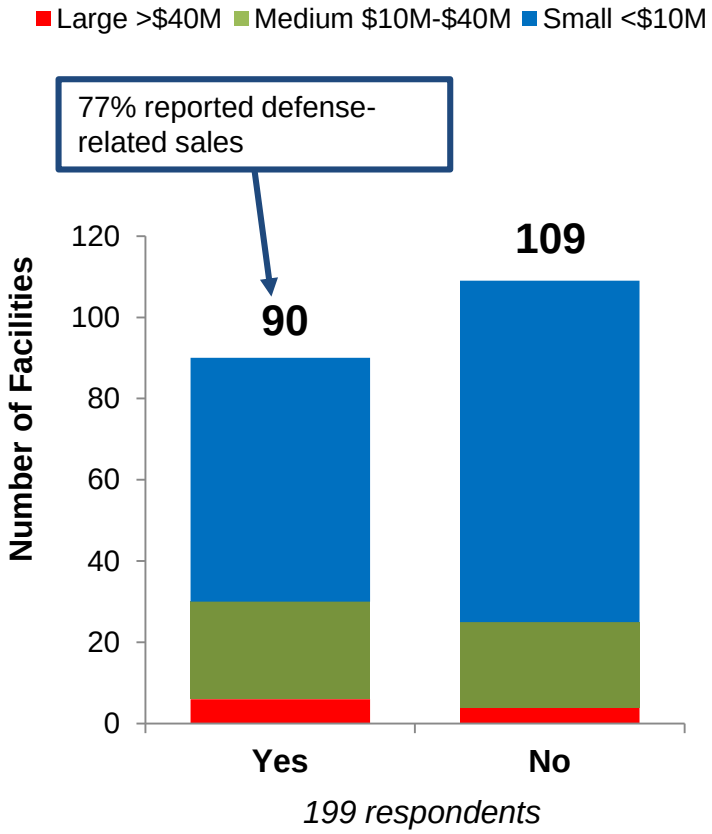
Q6a,A

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

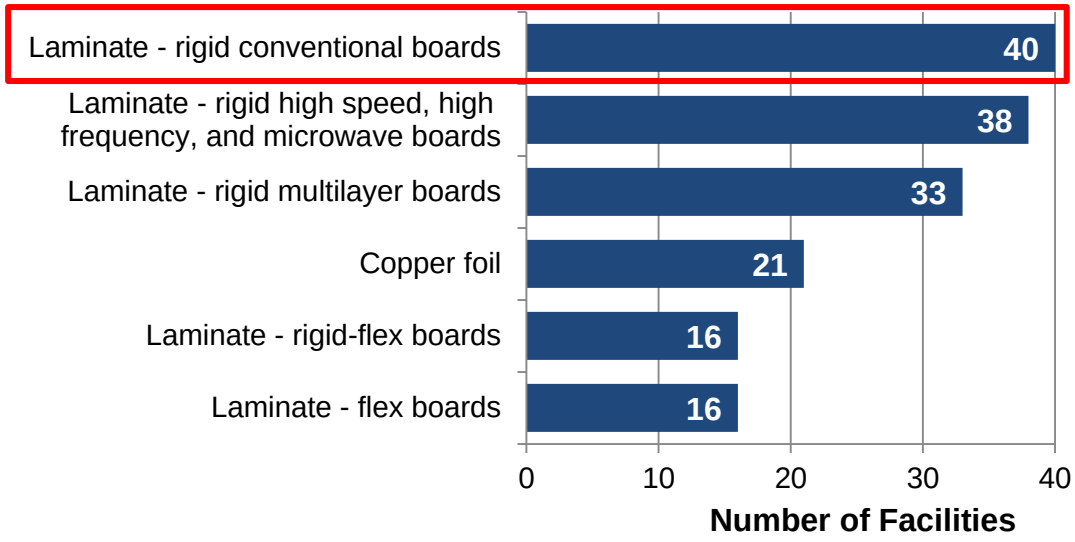
202 respondents

Materials - Supply Chain Disruptions - Example

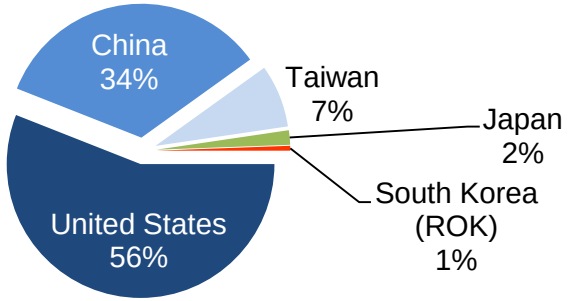
Does a reduction in U.S.-based companies that manufacture laminates and other circuit board-related materials create supply problems for this facility?



Top Experienced Material Supply Chain Disruptions (2012 to 2015)

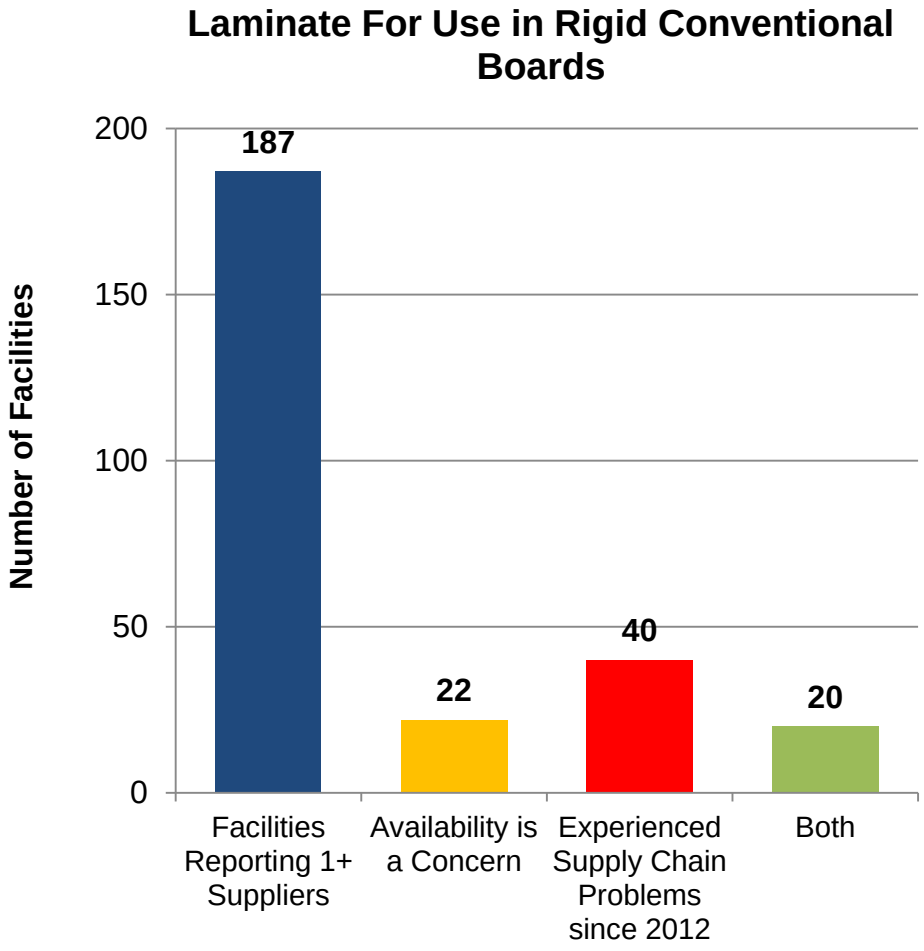


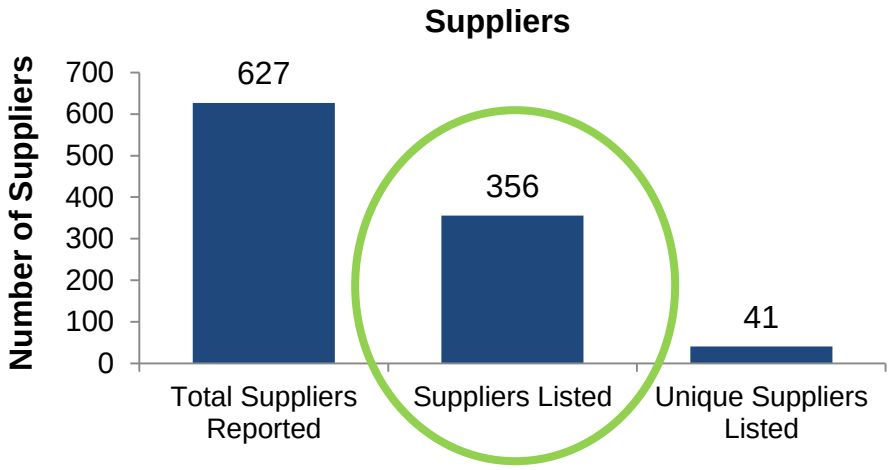
Suppliers Listed – Countries: Laminate – rigid conventional board

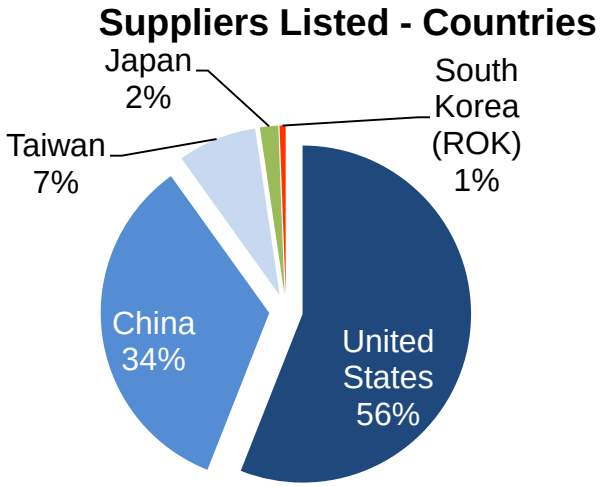


Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Materials - Laminate for Use in Rigid Conventional Boards





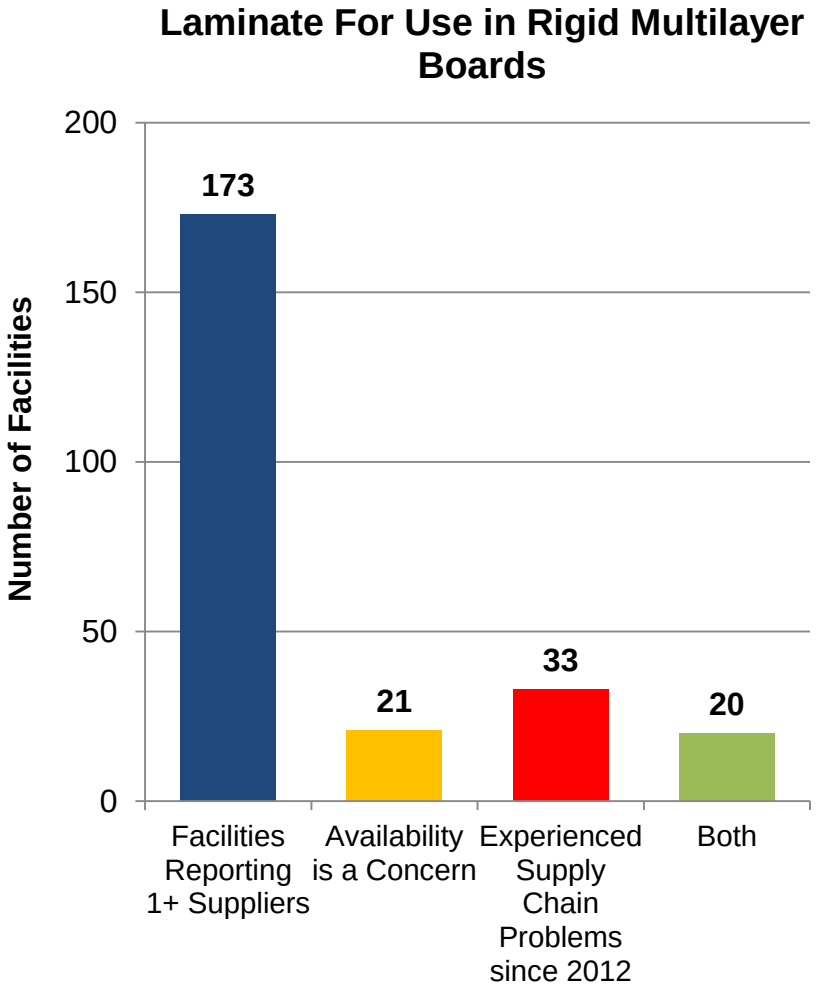


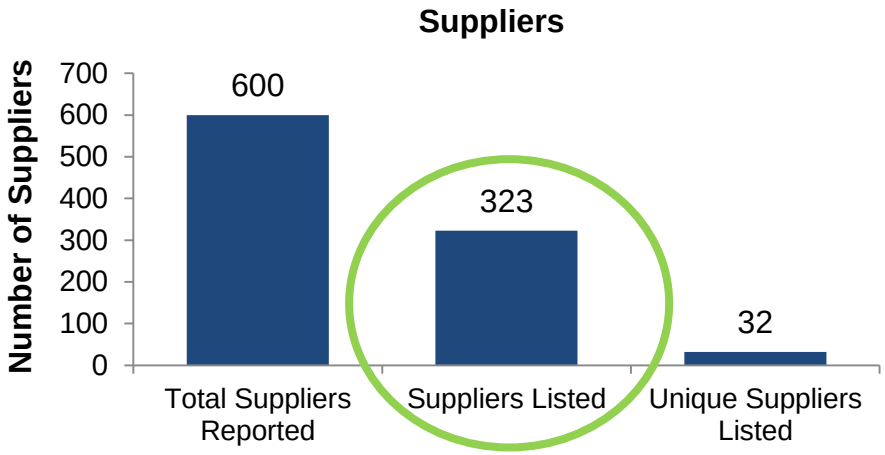
Q6a,A

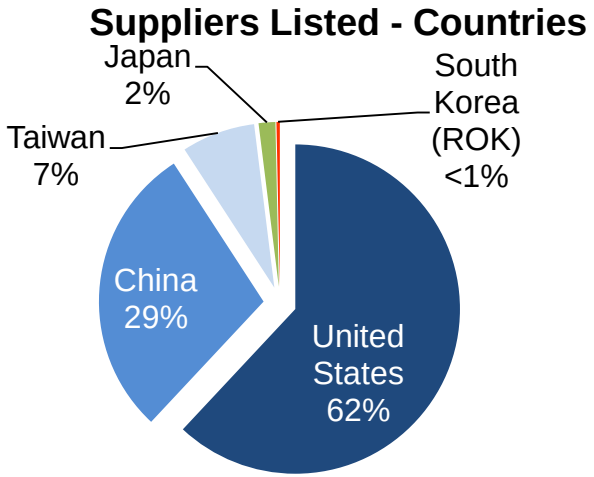
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Materials - Laminate for Use in Rigid Multilayer Boards





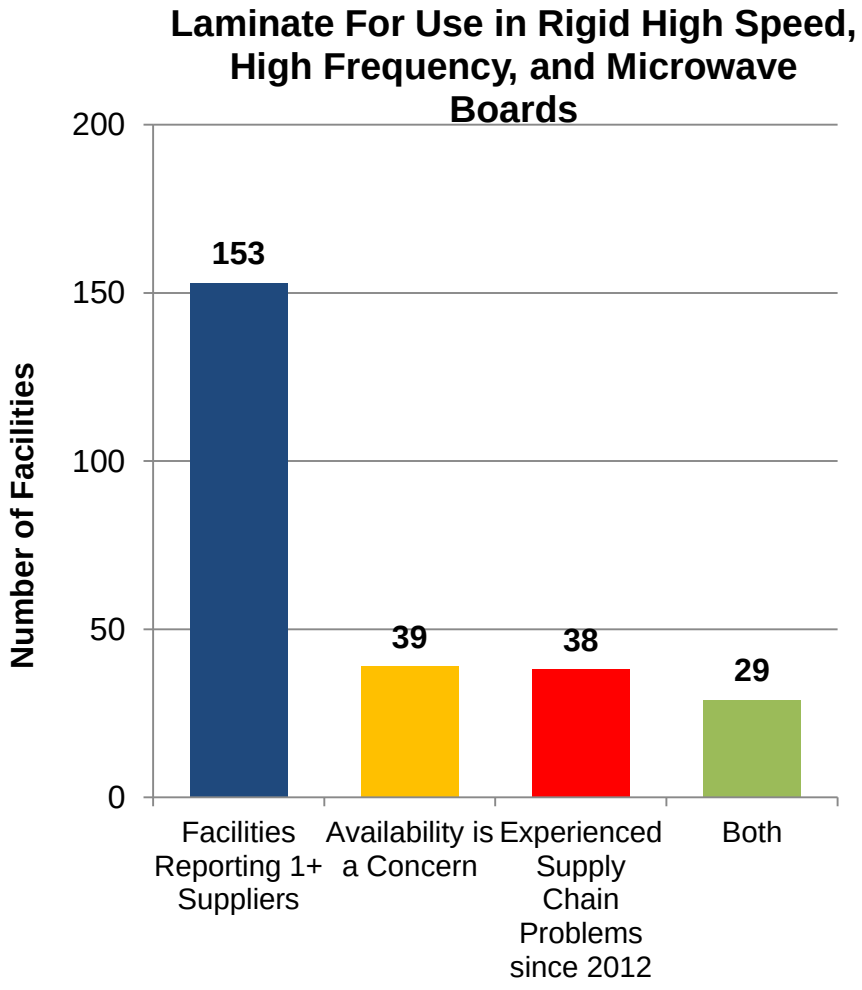


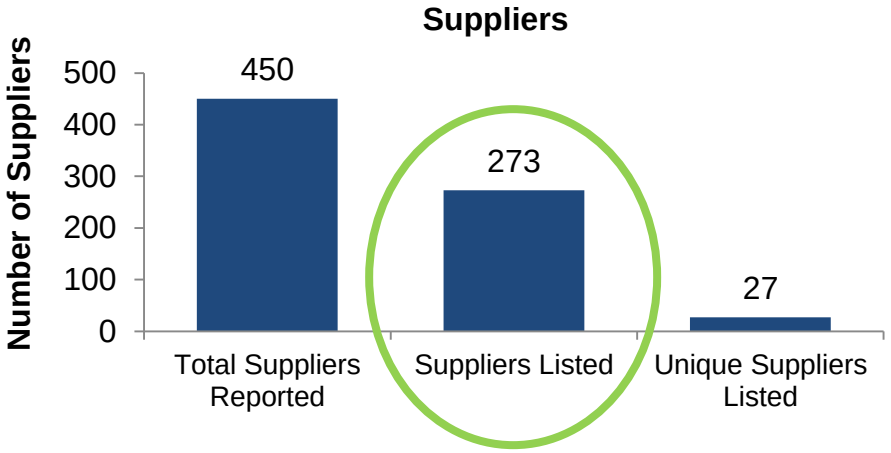
Q6a,A

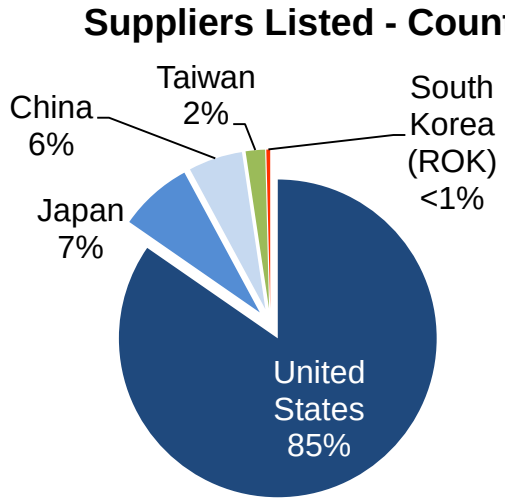
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Materials - Laminate for use in Rigid High Speed, High Frequency, and Microwave Boards







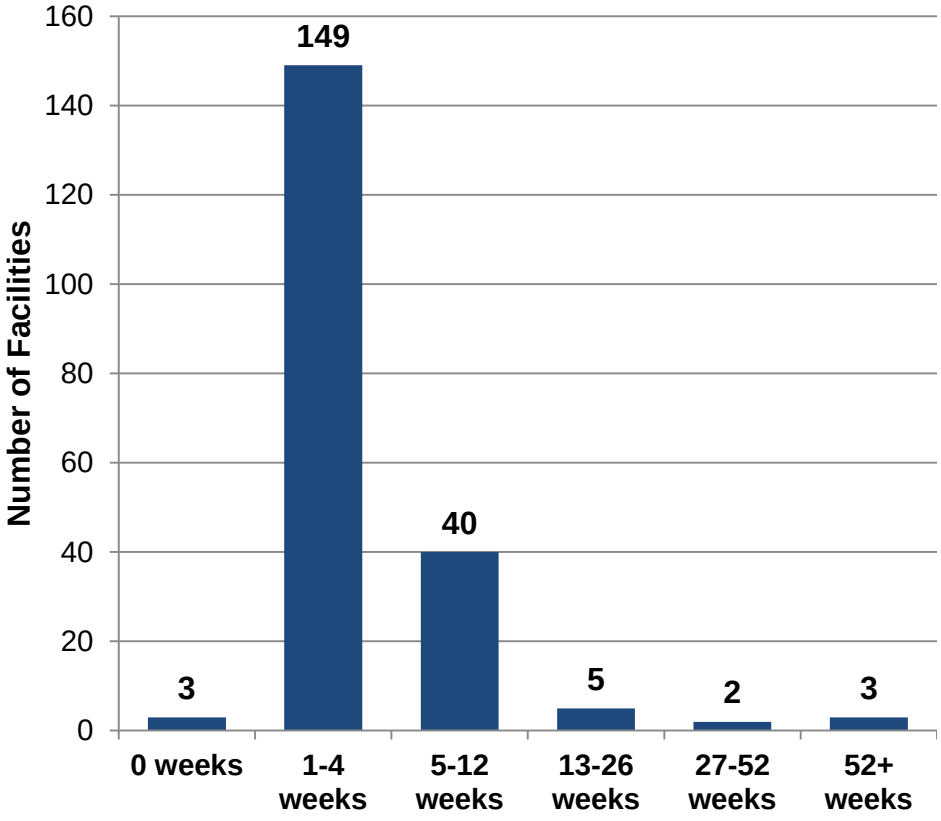
Q6a,A

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

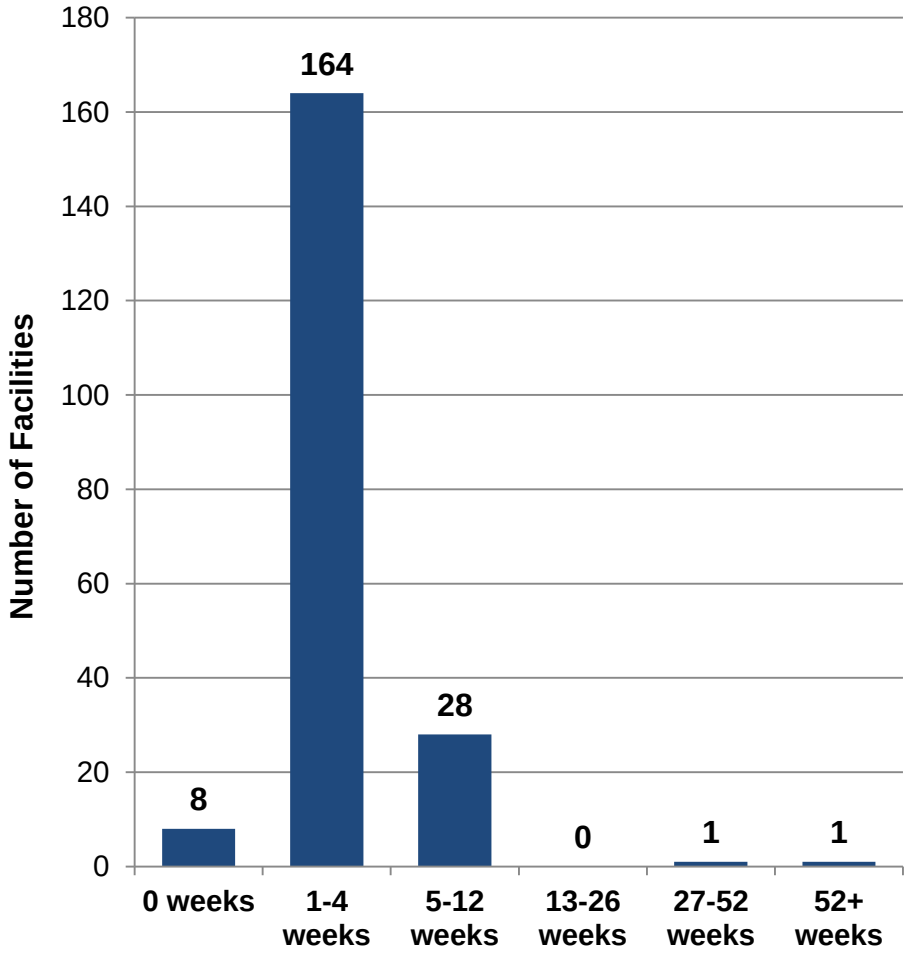
202 respondents

Materials - Impact of Supply Chain Disruptions

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?



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



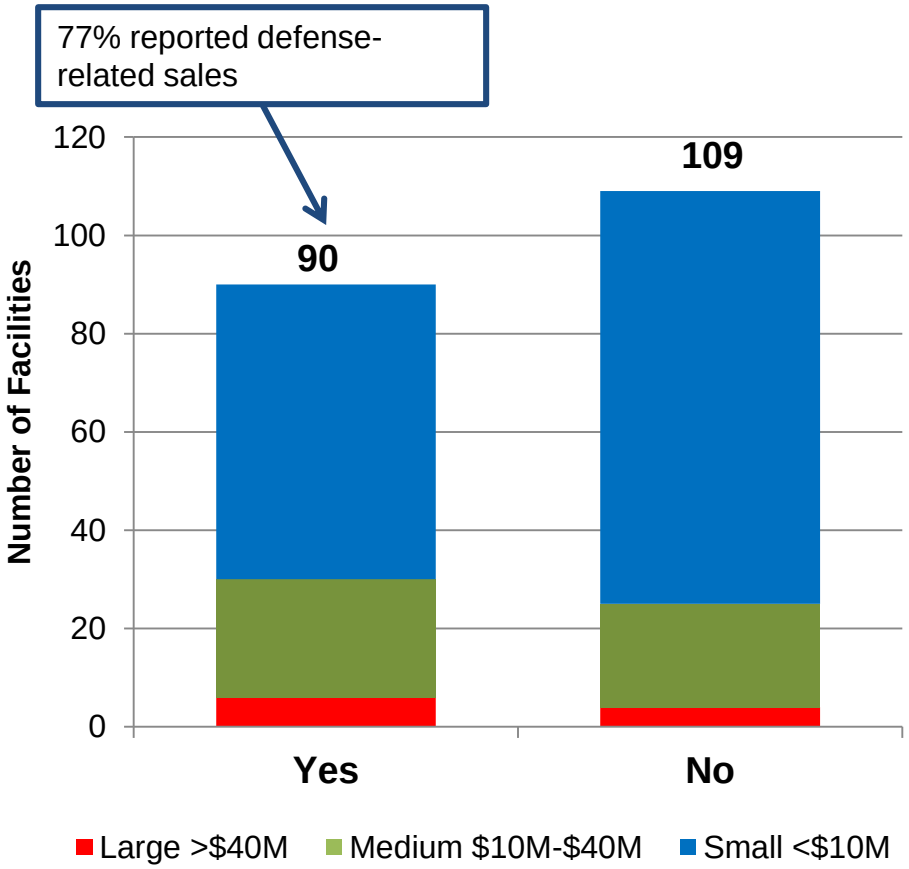
Q6b,A1/A2

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

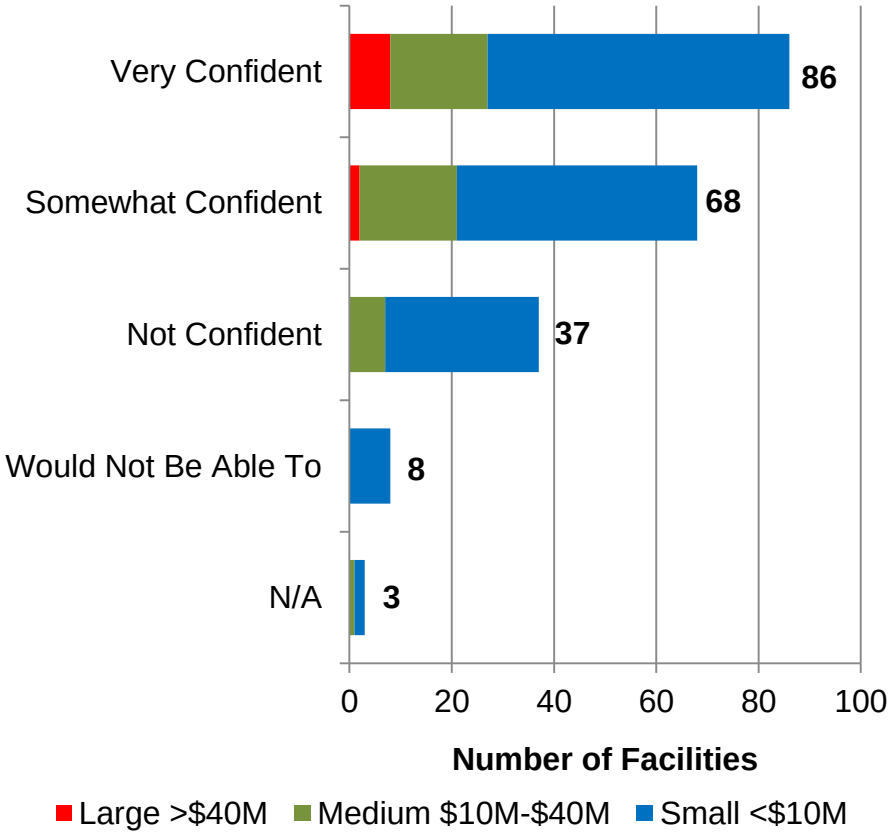
202 respondents

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?



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



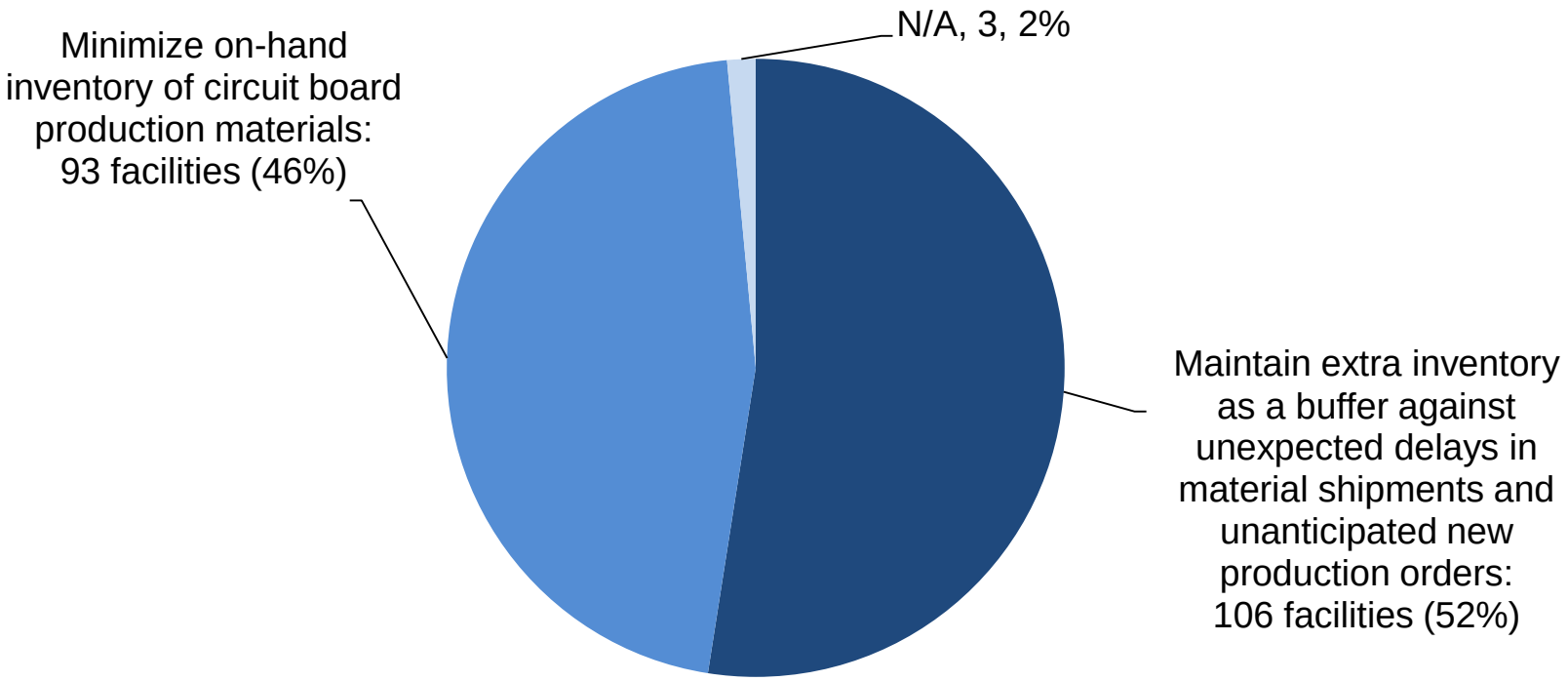
Q6b,A3/A4

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?

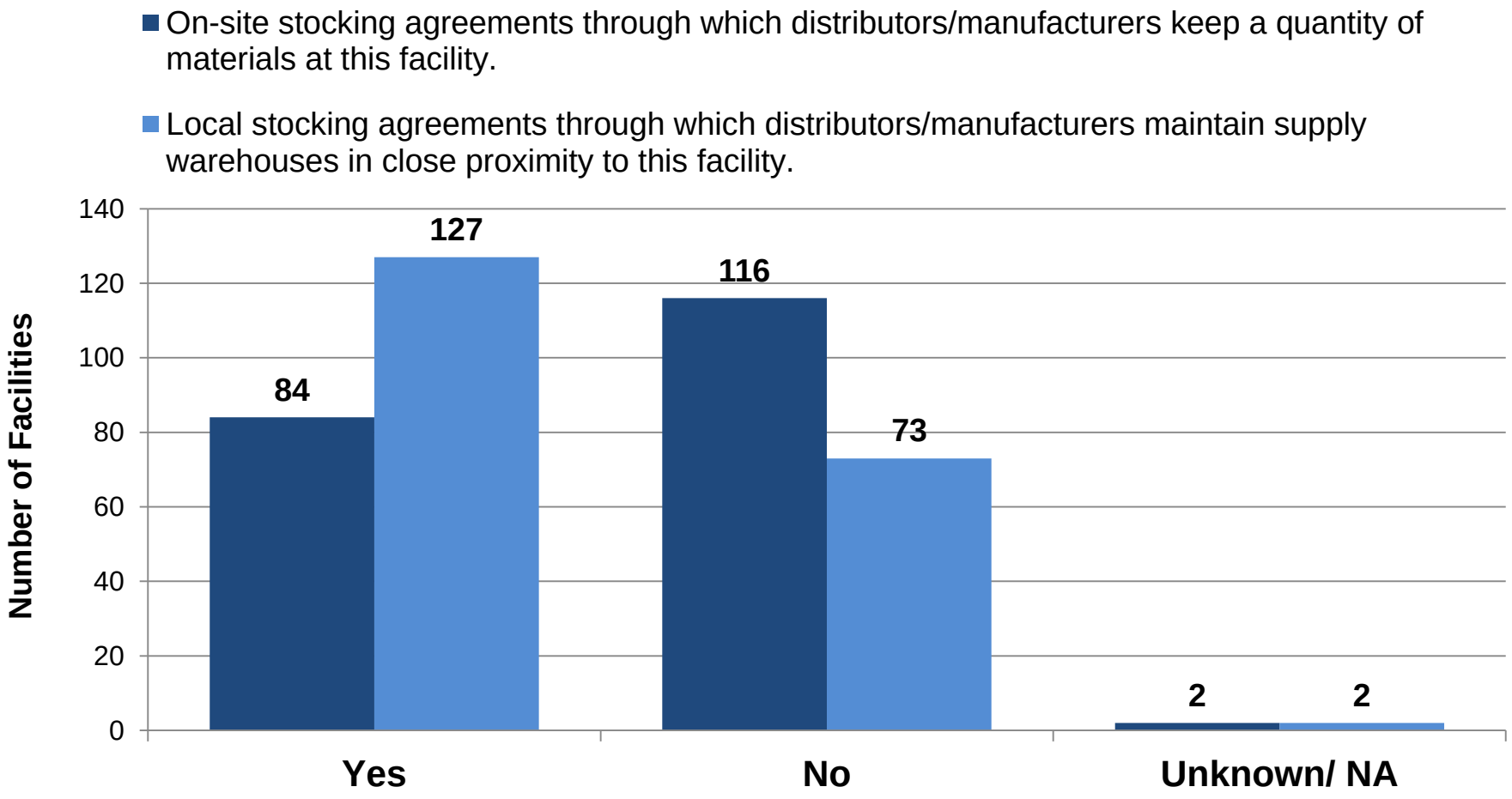


Q6b,B

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

202 respondents

Materials - Practices Used to Assure Availability of Bare PCB Materials

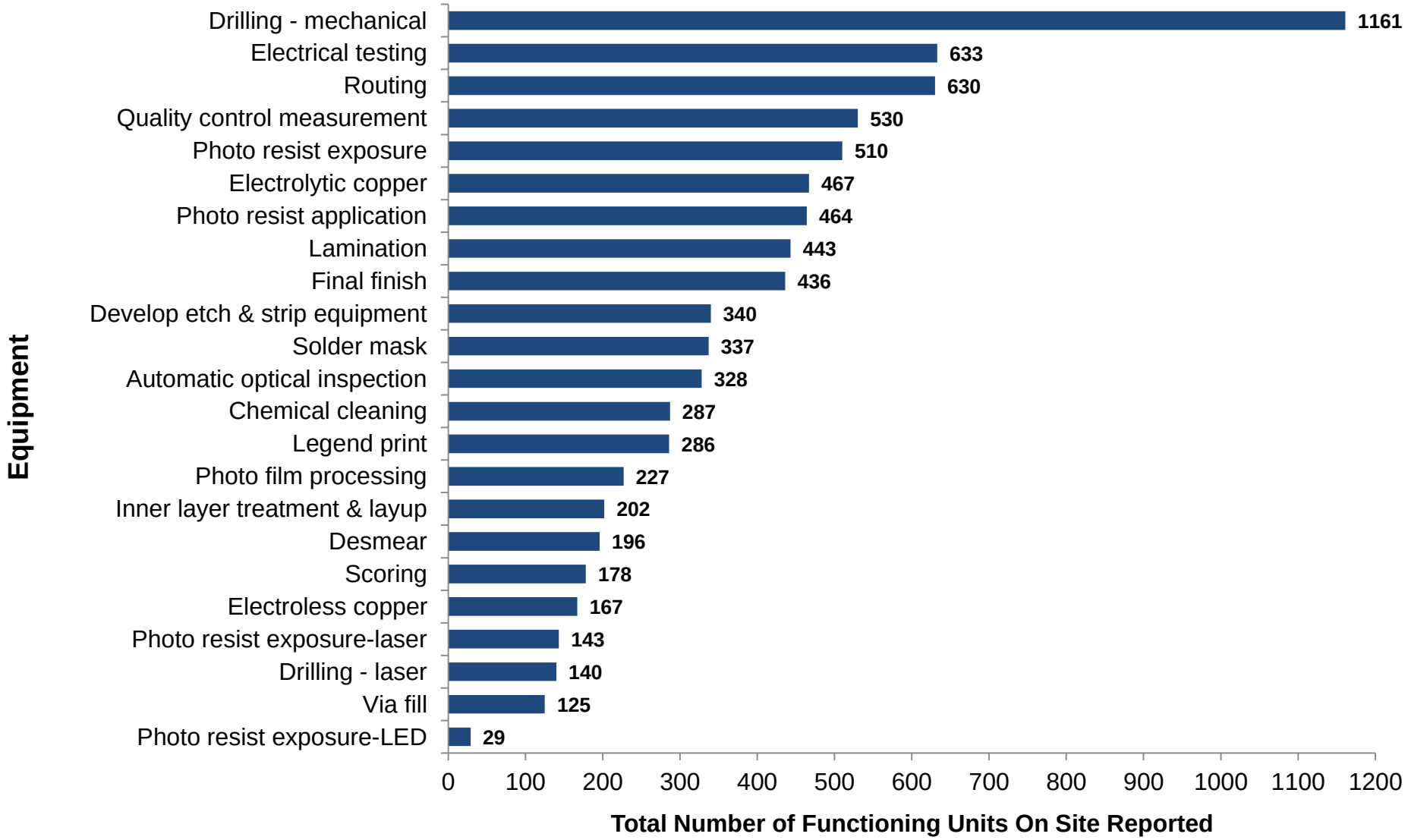


Q6b,C

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 Functioning Units On Site

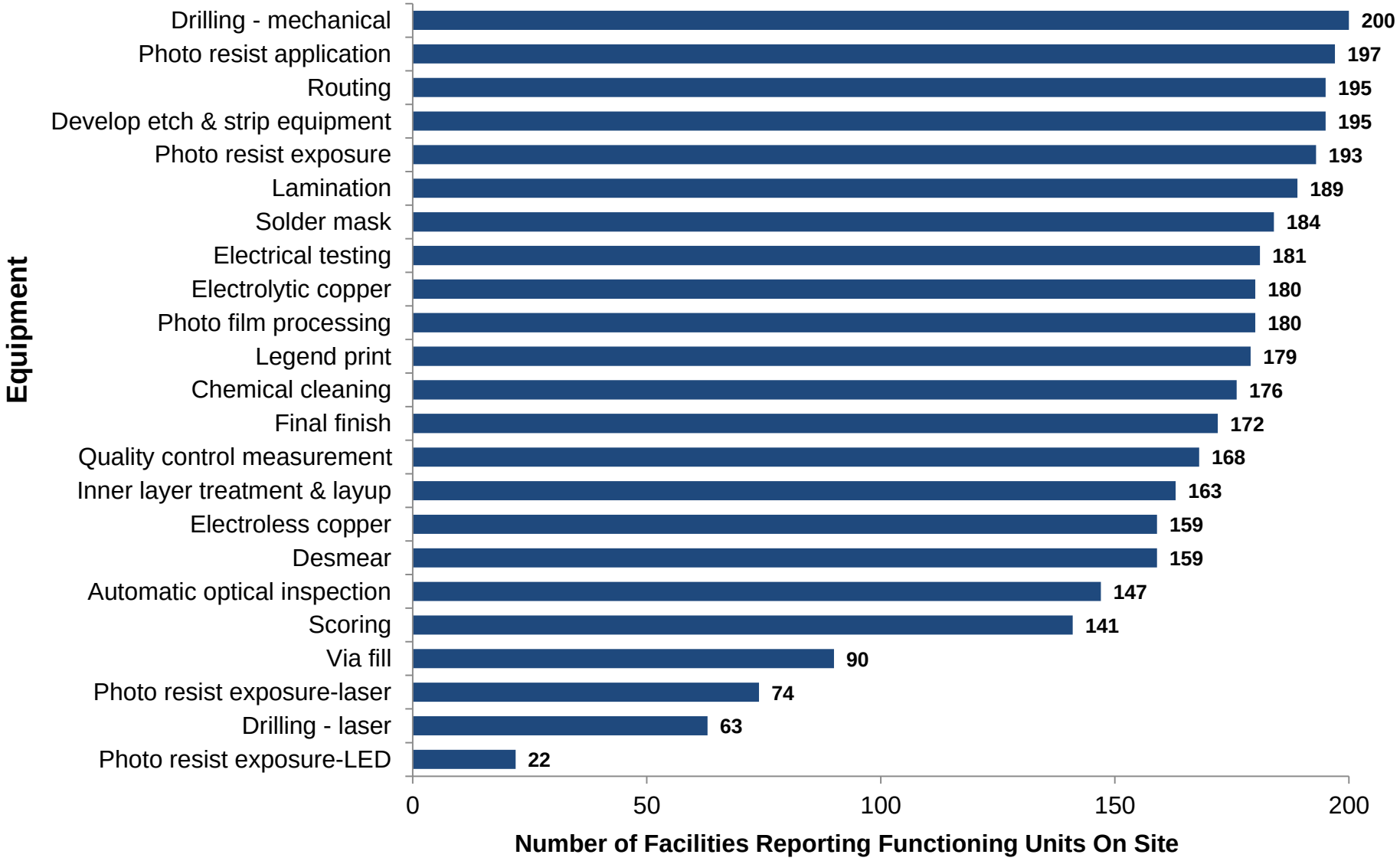


Q6c,A

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

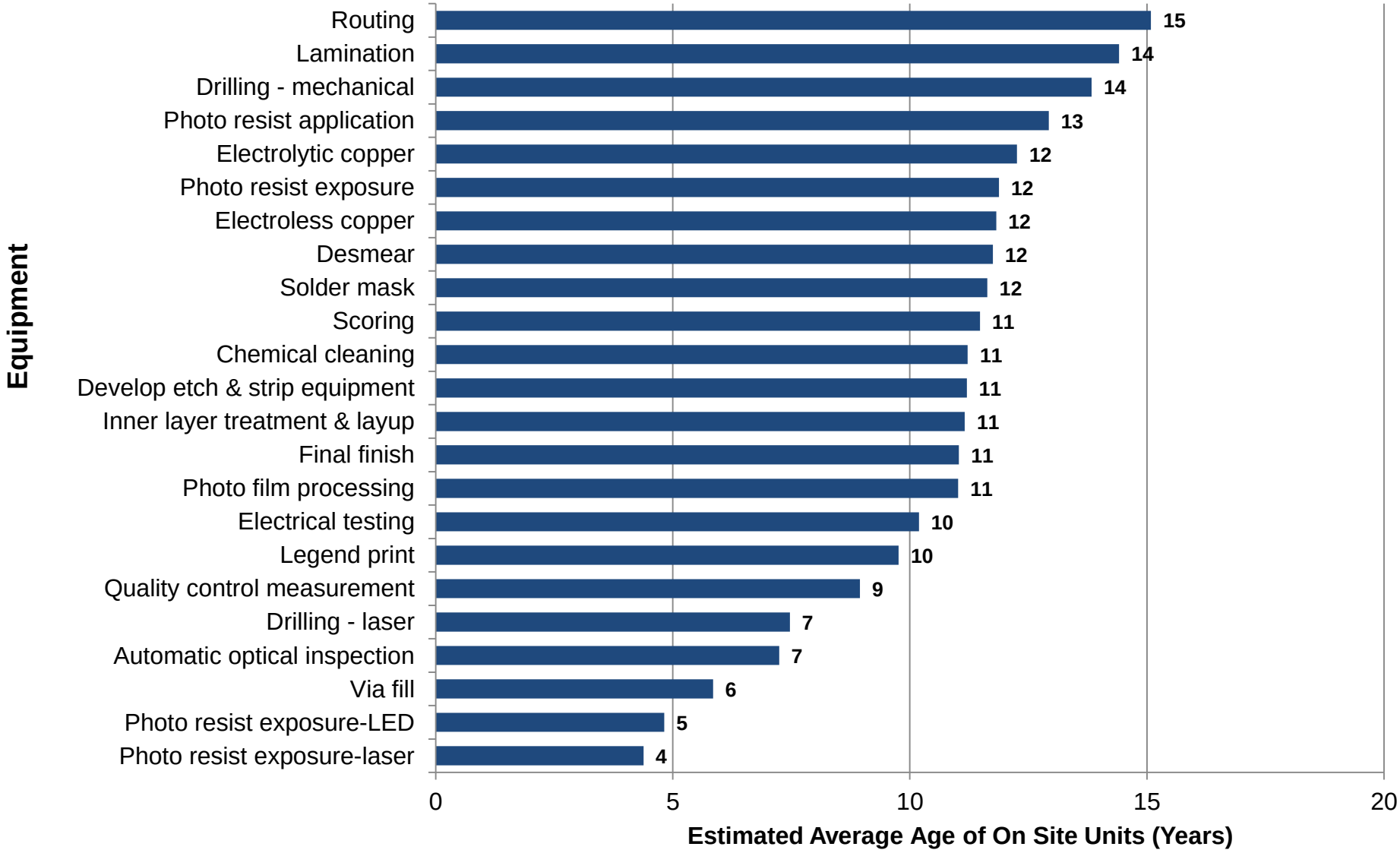


Q6c,A

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



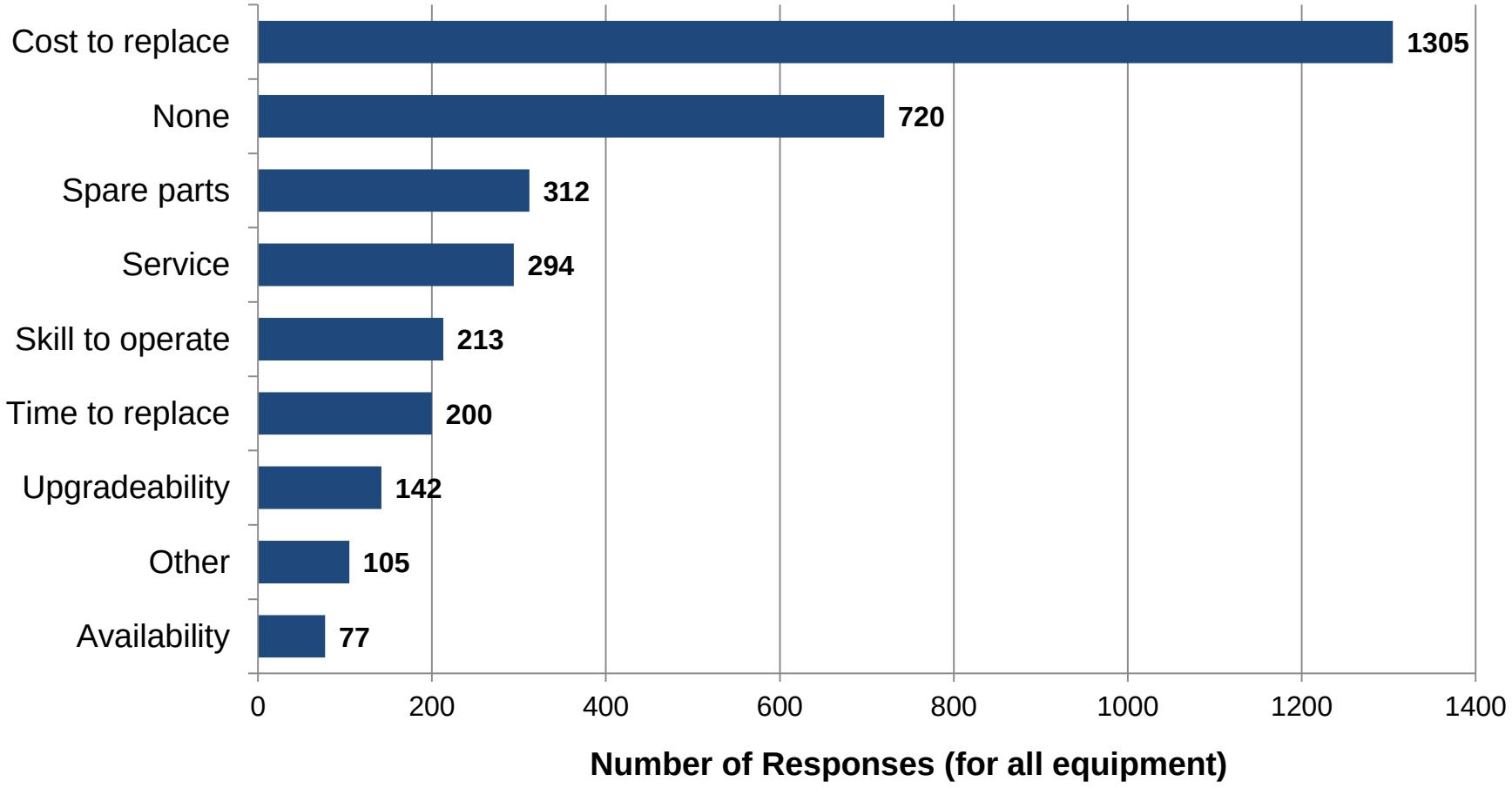
Q6c,A

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

202 respondents

Equipment – Primary Concerns

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



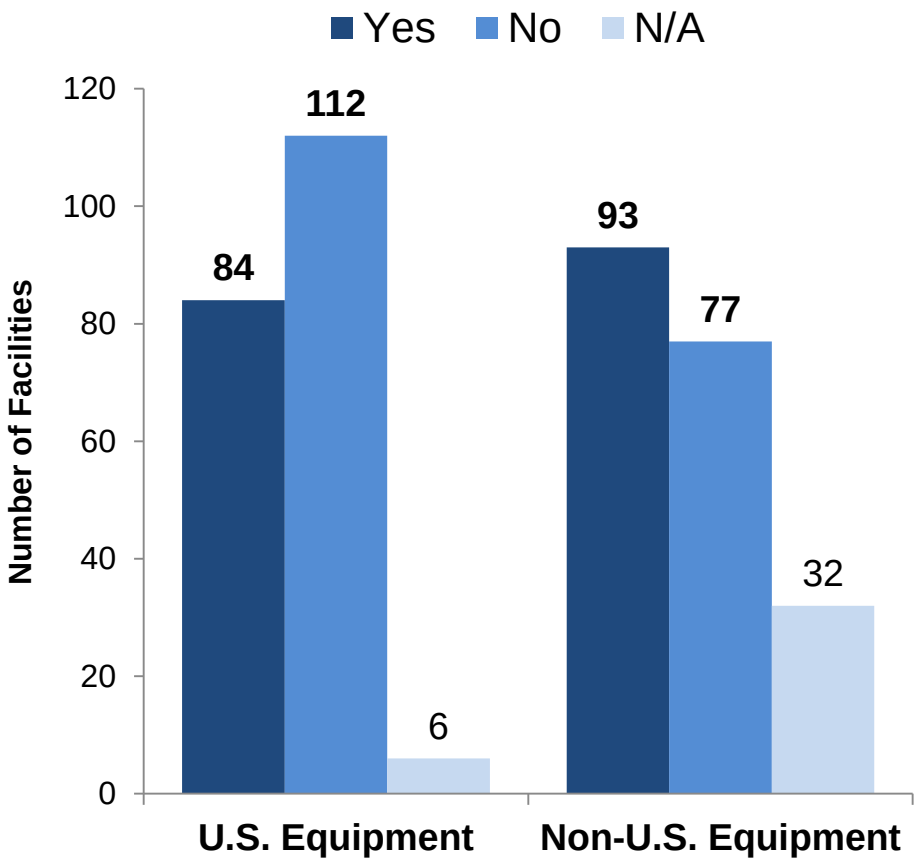
Q6c,A

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

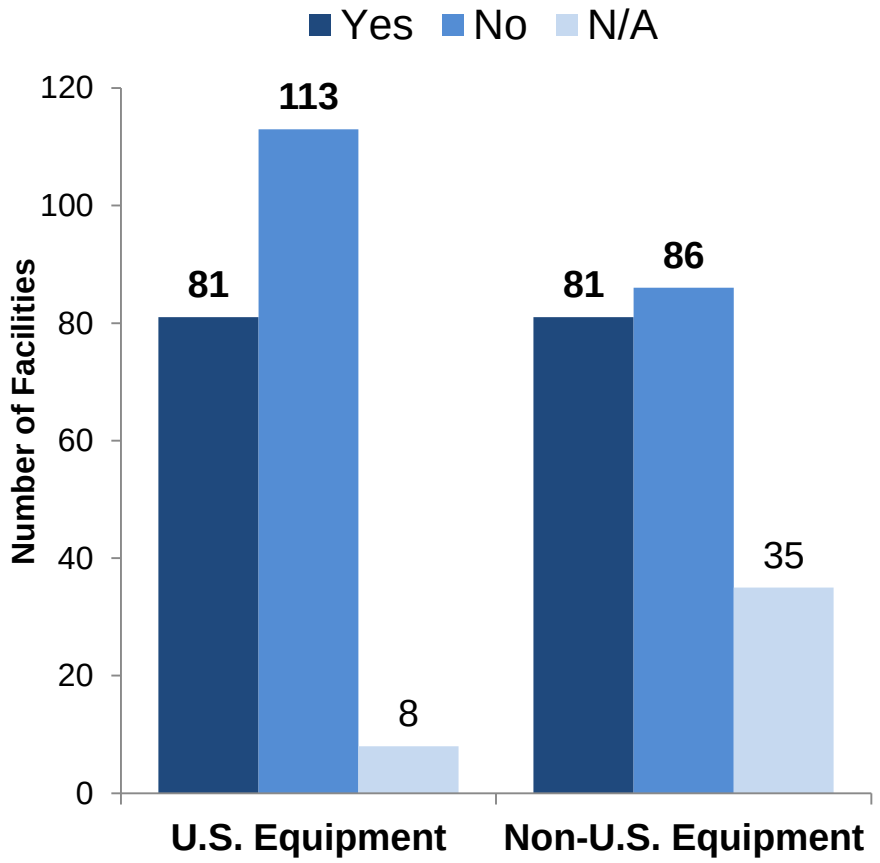
202 respondents

Equipment - Trouble Obtaining Parts and Service

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



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



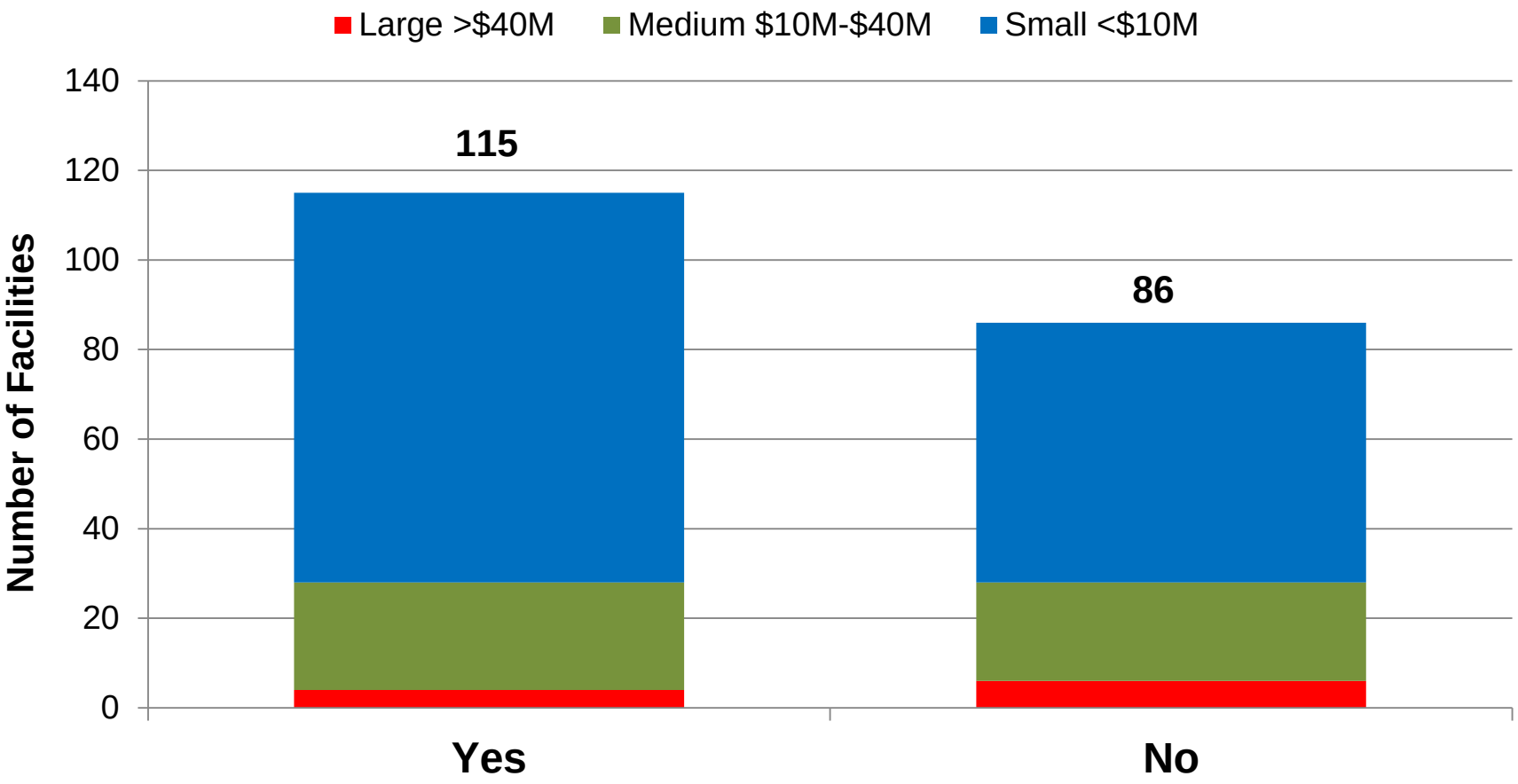
Q6c, B

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

202 respondents

Equipment - Manufacturing Limitations

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



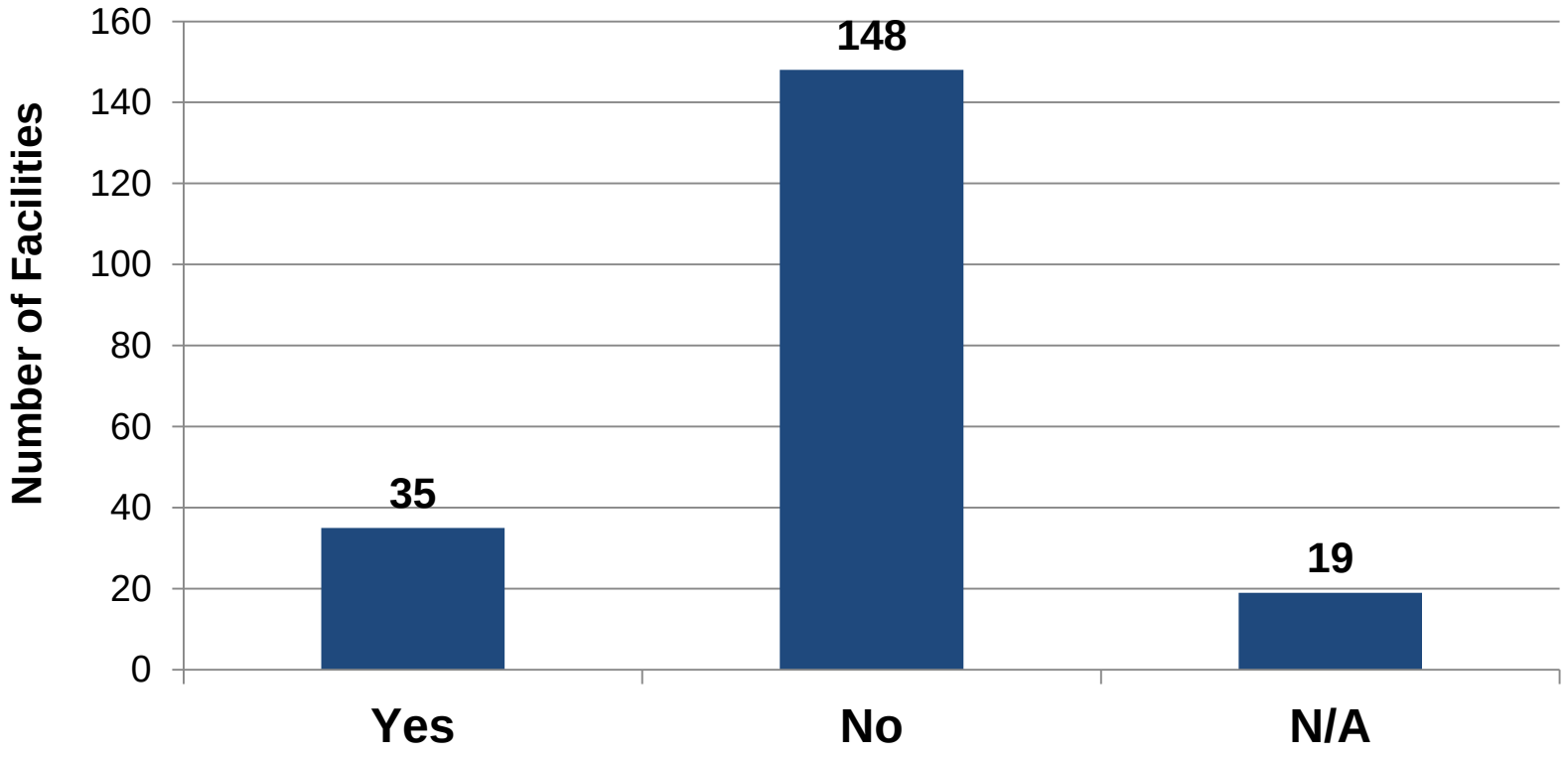
Q6c,C

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?



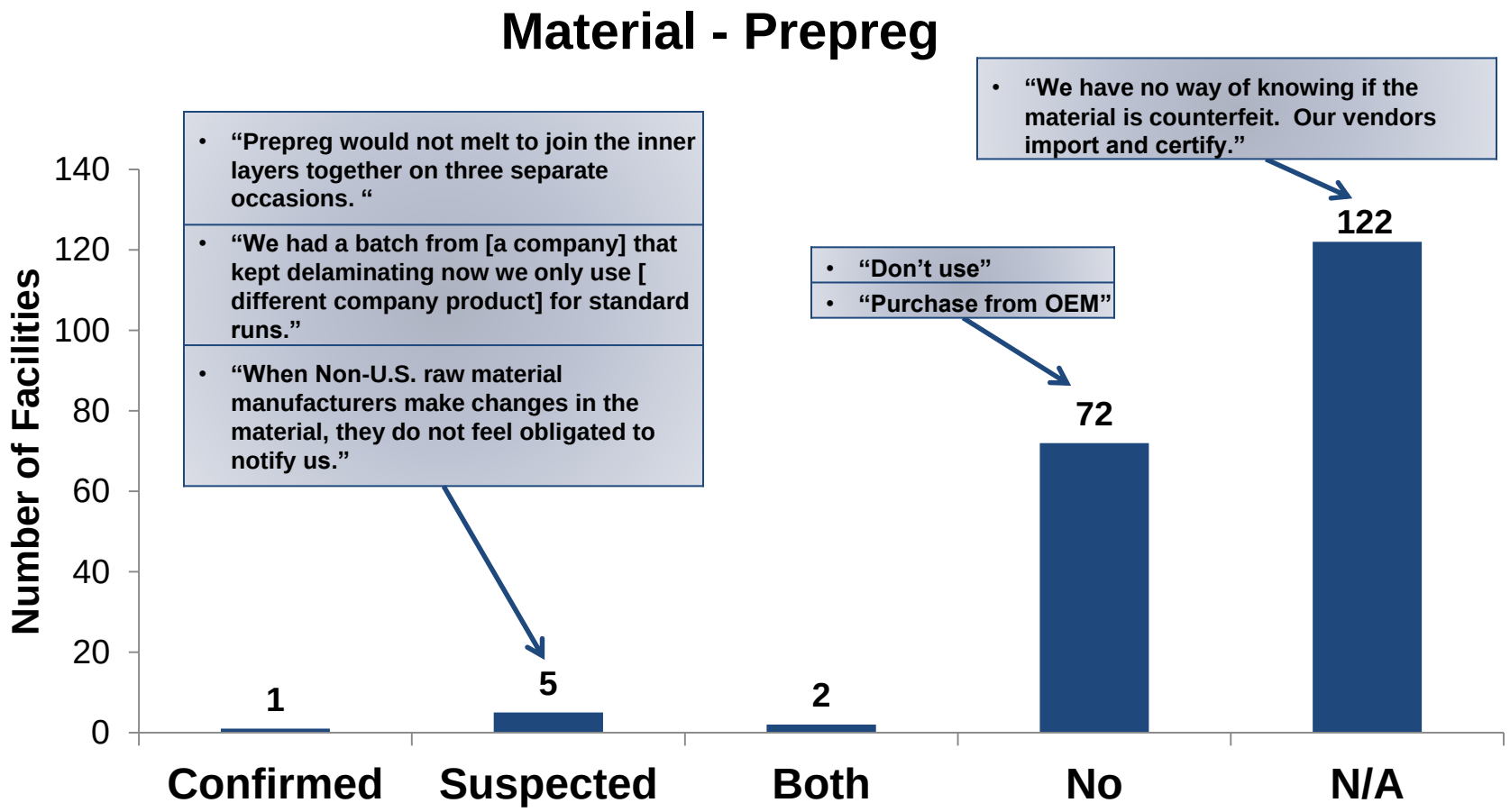
Q6c,C

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?



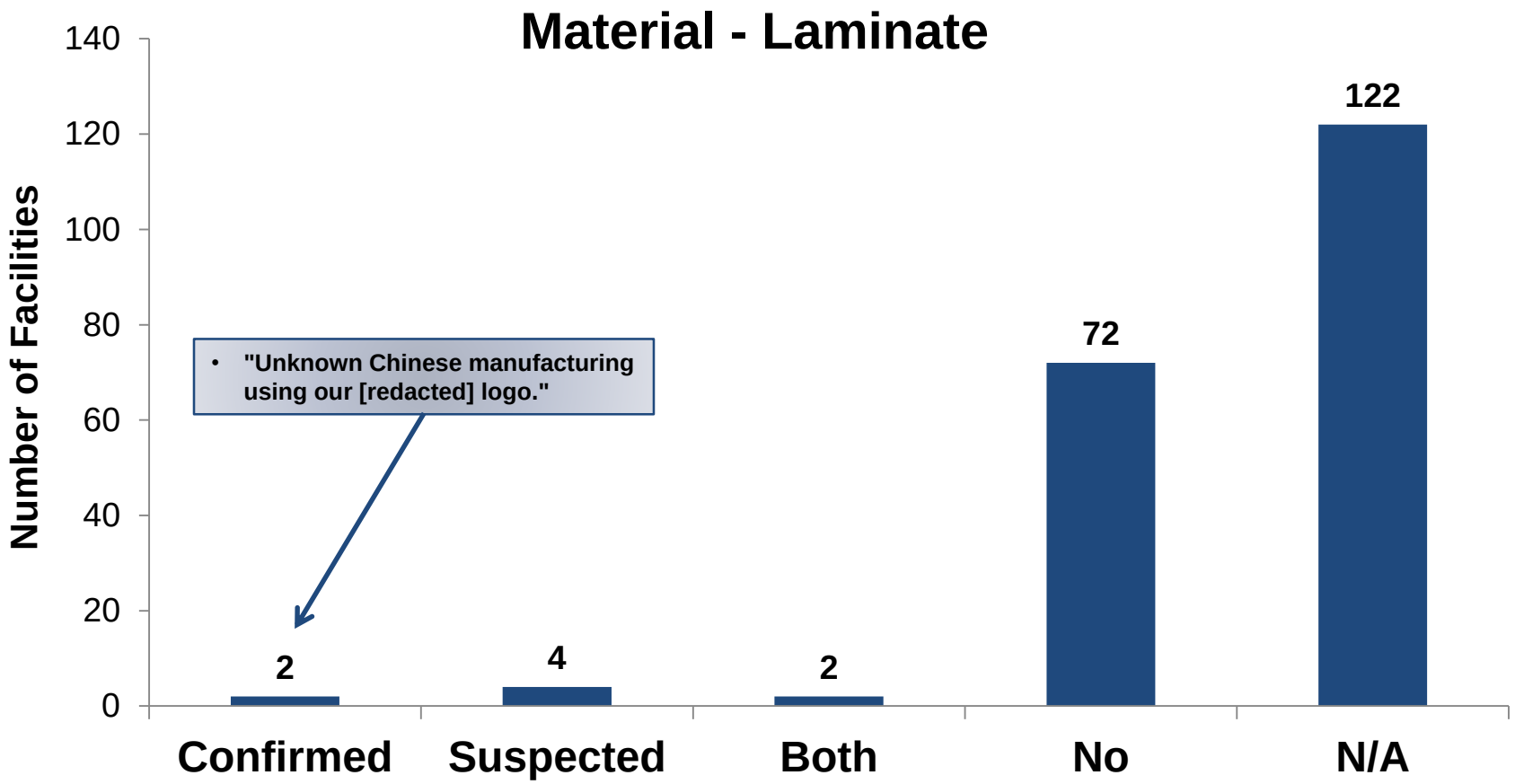
Q6d,A

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?



Q6d,A

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?

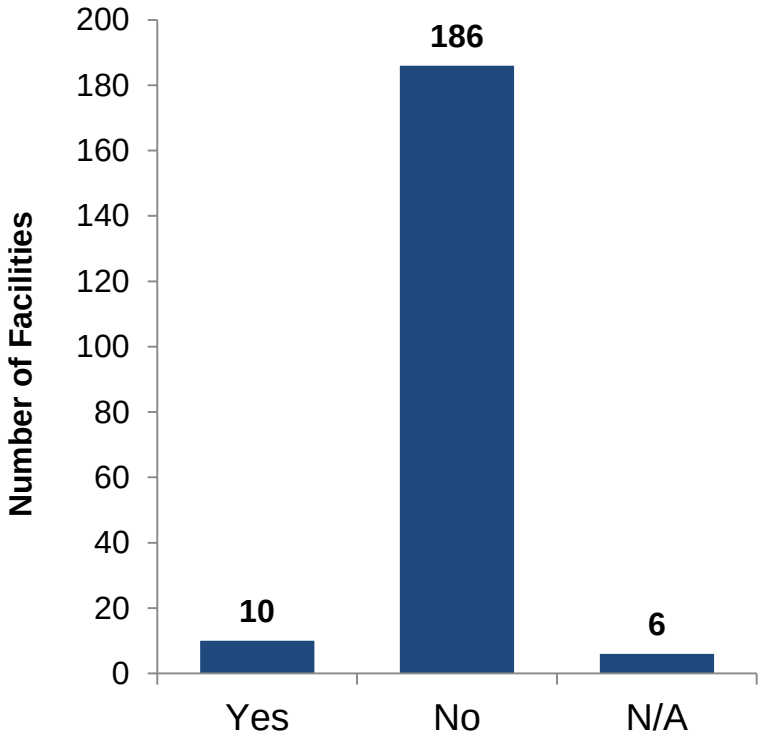
Q6d,A

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

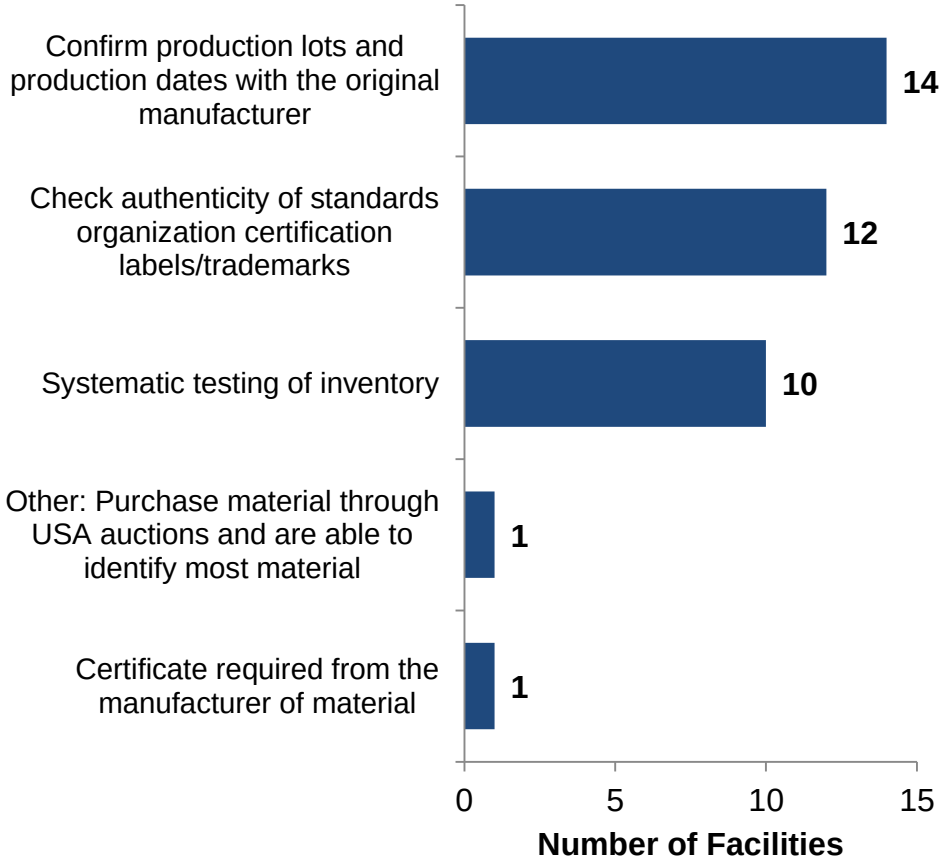
202 respondents

Materials – Bare PCB 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?



Q6d,B

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.

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.

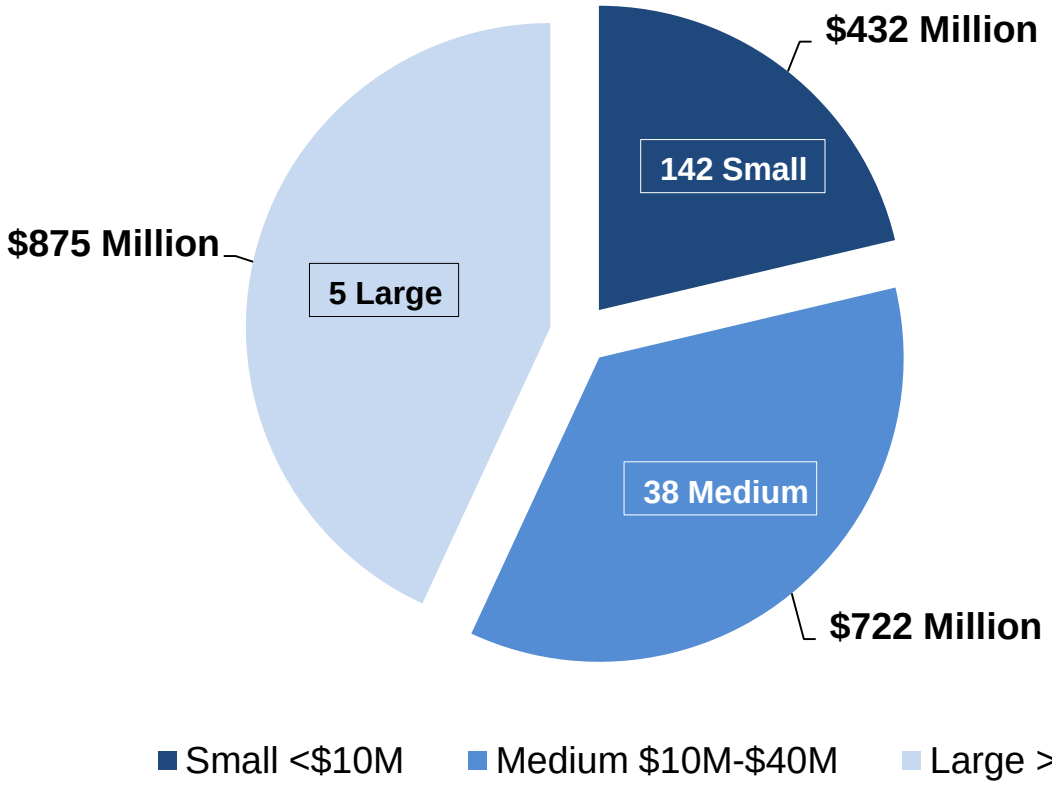
- From 2012 to 2015, U.S. sales growth for Bare PCBs was driven by large and medium-sized companies which were responsible for 66 percent and 43 percent of growth, respectively. Small-sized companies were the only category to report an increase in exports sales from 2012 to 2015, from $17M to $25M. However, 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
U.S. Bare Printed Circuit Board Industry Assessment – 2017

Bare PCB Sales (2015)

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



Companies:

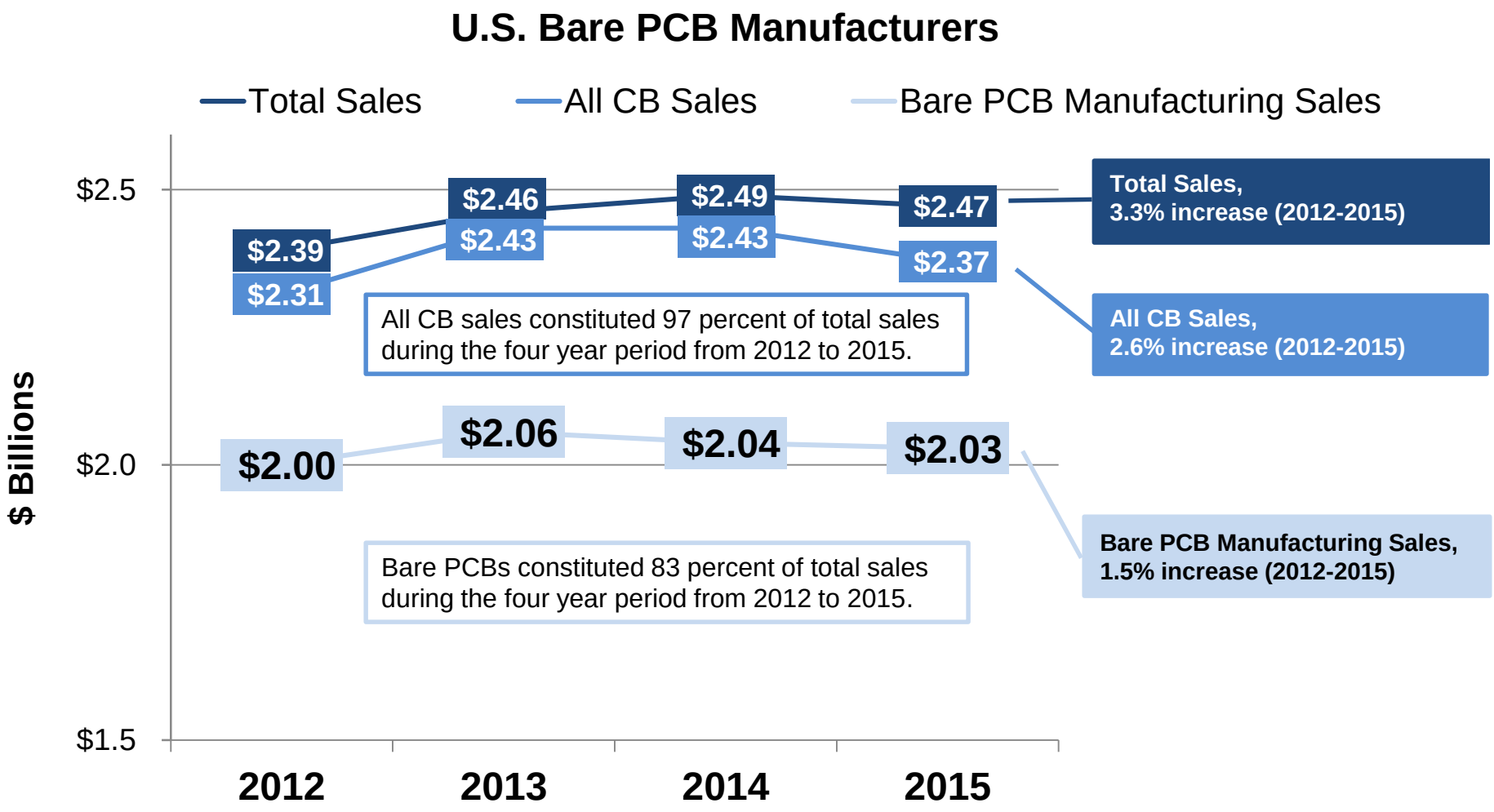
- 10 Publicly Traded
- 175 Privately Held

Q7

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

185 respondents

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



Q7

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

202 respondents

Breakout of Industry Sales (2012-2015)

Total Sales, All CB Sales, and Bare CB Sales

Record in $ Millions e.g. $12,000,000.00 = survey input $12

	2012		2013		2014		2015	
	U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.
Total Sales (in $)	$ 1,946	$ 441	$ 2,030	$ 434	$ 2,107	$ 384	$ 2,089	$ 380
Total Government Sales	$ 470	$ 6	$ 530	$ 6	$ 544	$ 5	$ 538	$ 9
All Circuit Board-Related Sales - including design, manufacture, and assembly (in $)	$ 1,885	$ 428	$ 2,000	$ 429	$ 2,066	$ 368	$ 2,010	$ 360
All Circuit Board-Related Government Sales	$ 460	$ 6	$ 513	$ 6	$ 536	$ 5	$ 511	$ 9
Bare Circuit Board Manufacturing Sales - excluding design and assembly (in $)	$ 1,698	$ 306	$ 1,731	$ 332	$ 1,761	$ 280	$ 1,763	$ 266
Bare Circuit Board Government Sales	$ 386	$ 5	$ 408	$ 6	$ 421	$ 5	$ 453	$ 8

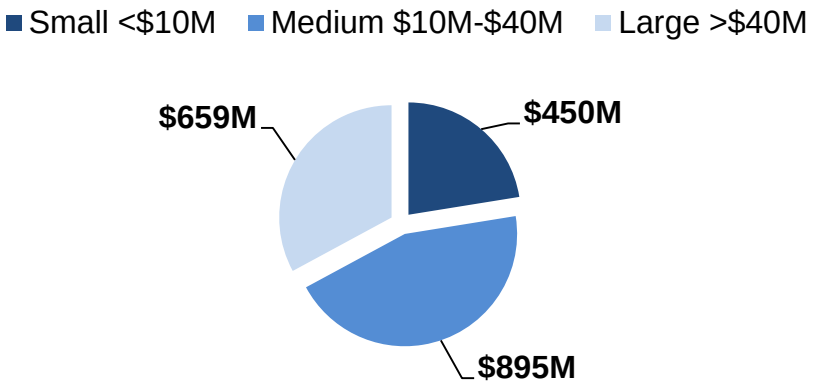
Q7

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

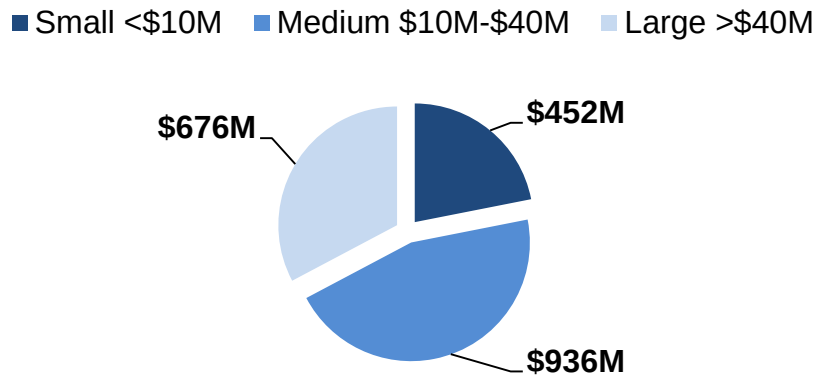
202 respondents

Bare PCB Sales – by Facility Size (2012-2015)

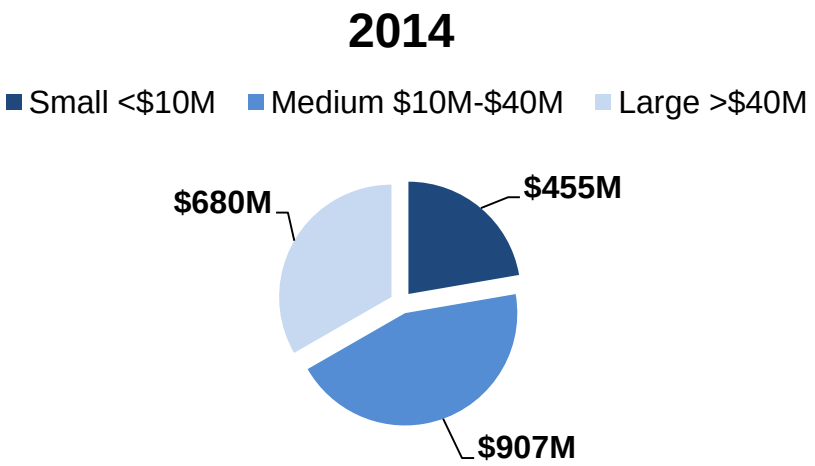
2012



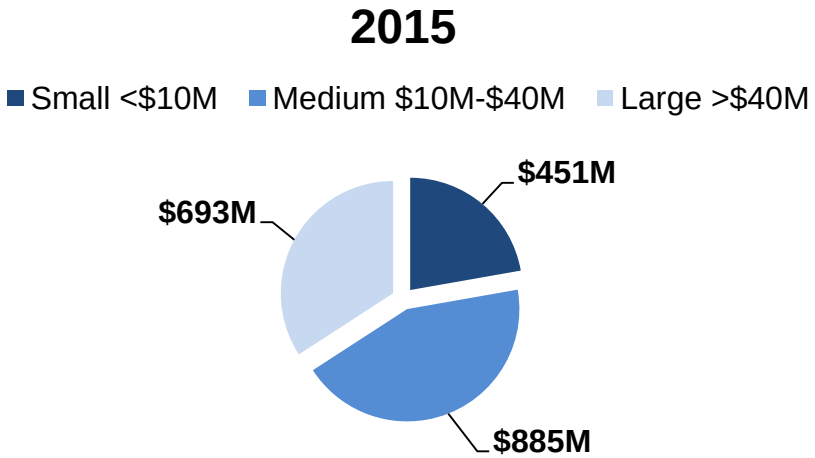
2013



2014



2015



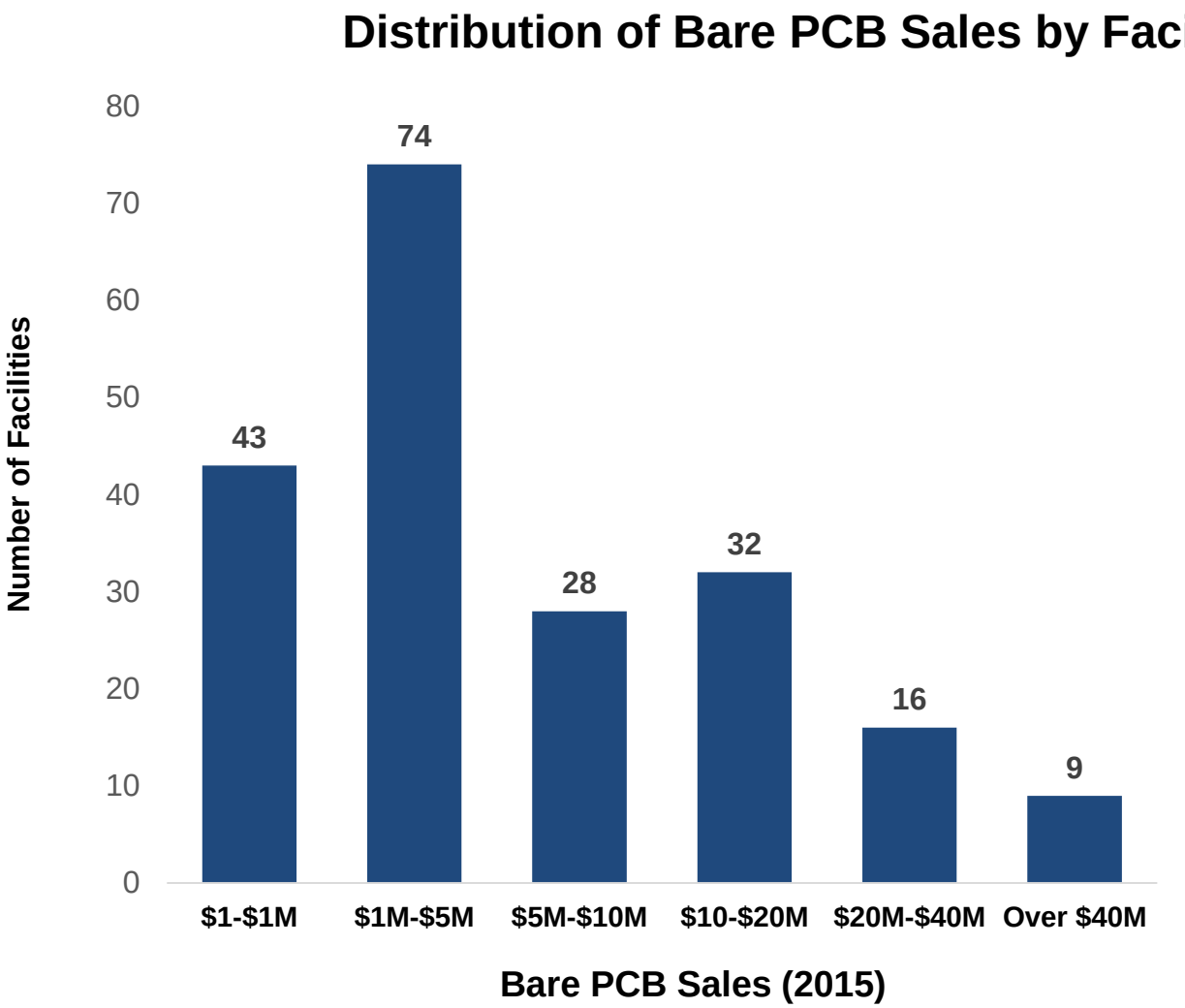
Small: Under $10M in annual sales **Medium: $10M-$40M in annual sales** **Large: Over $40M in annual sales**

Q7

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

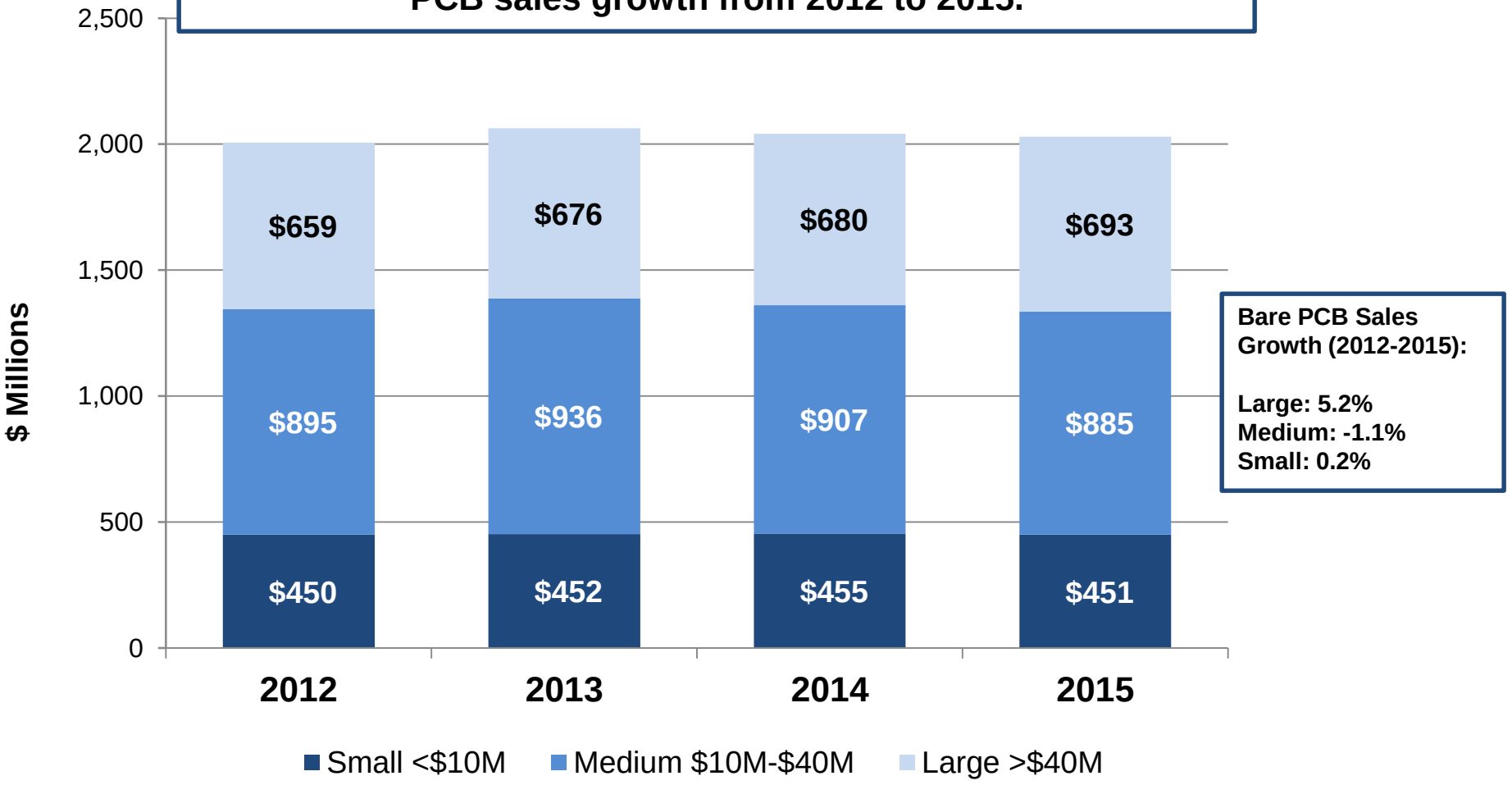
Q7

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

202 respondents

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.



Bare PCB Sales Growth (2012-2015):

Large: 5.2%
Medium: -1.1%
Small: 0.2%

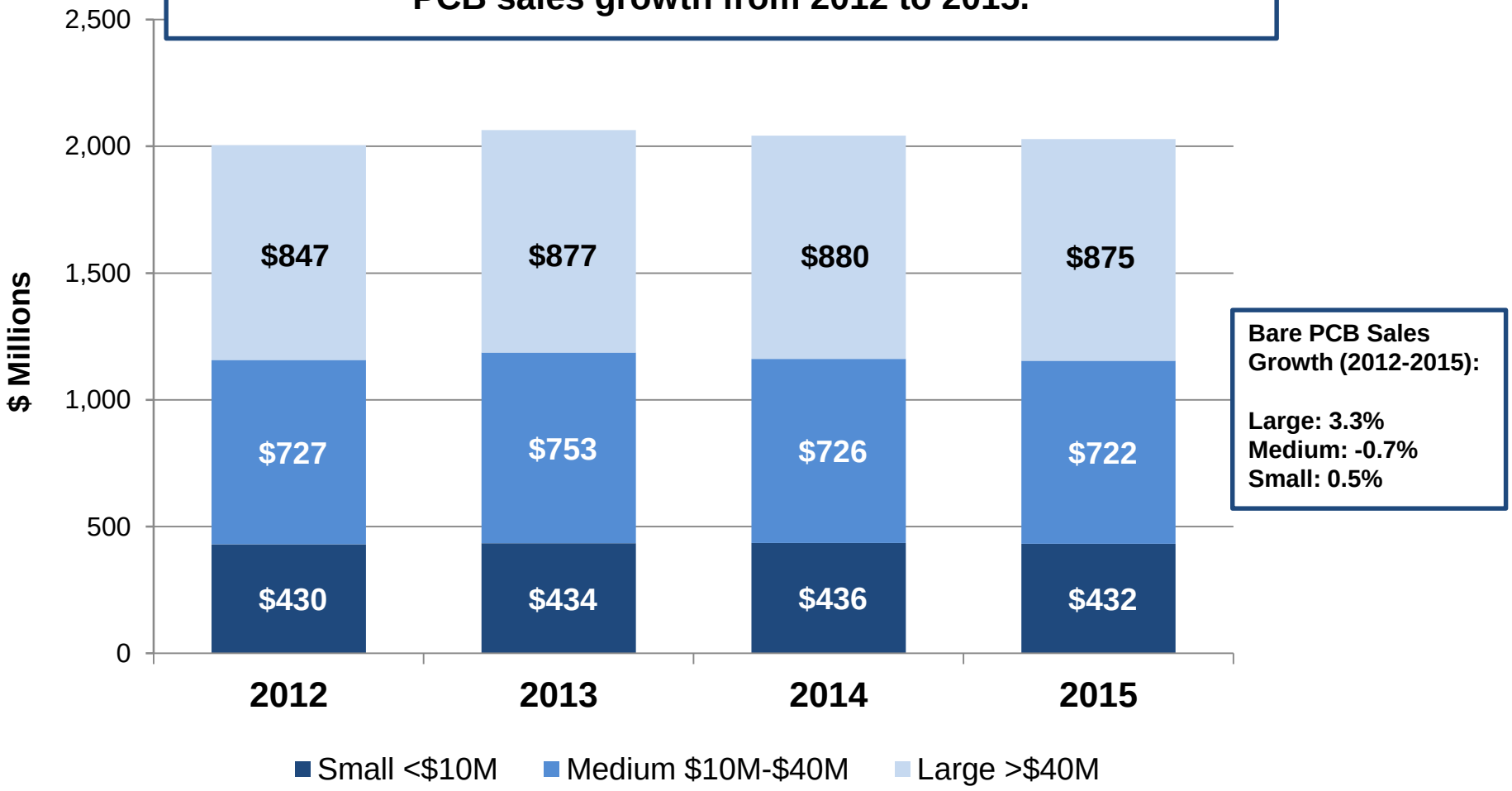
Q7

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

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.

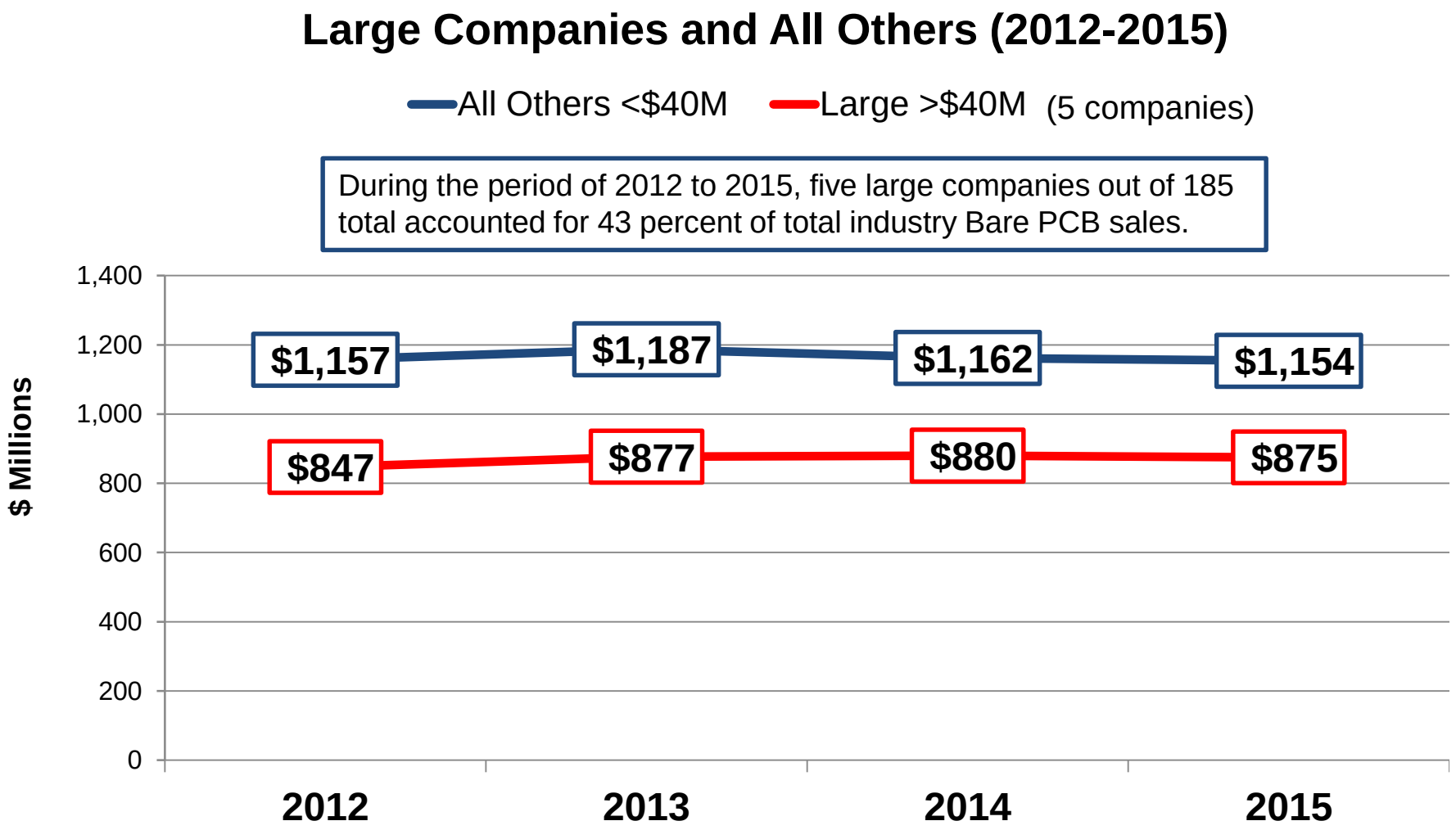


Q7

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

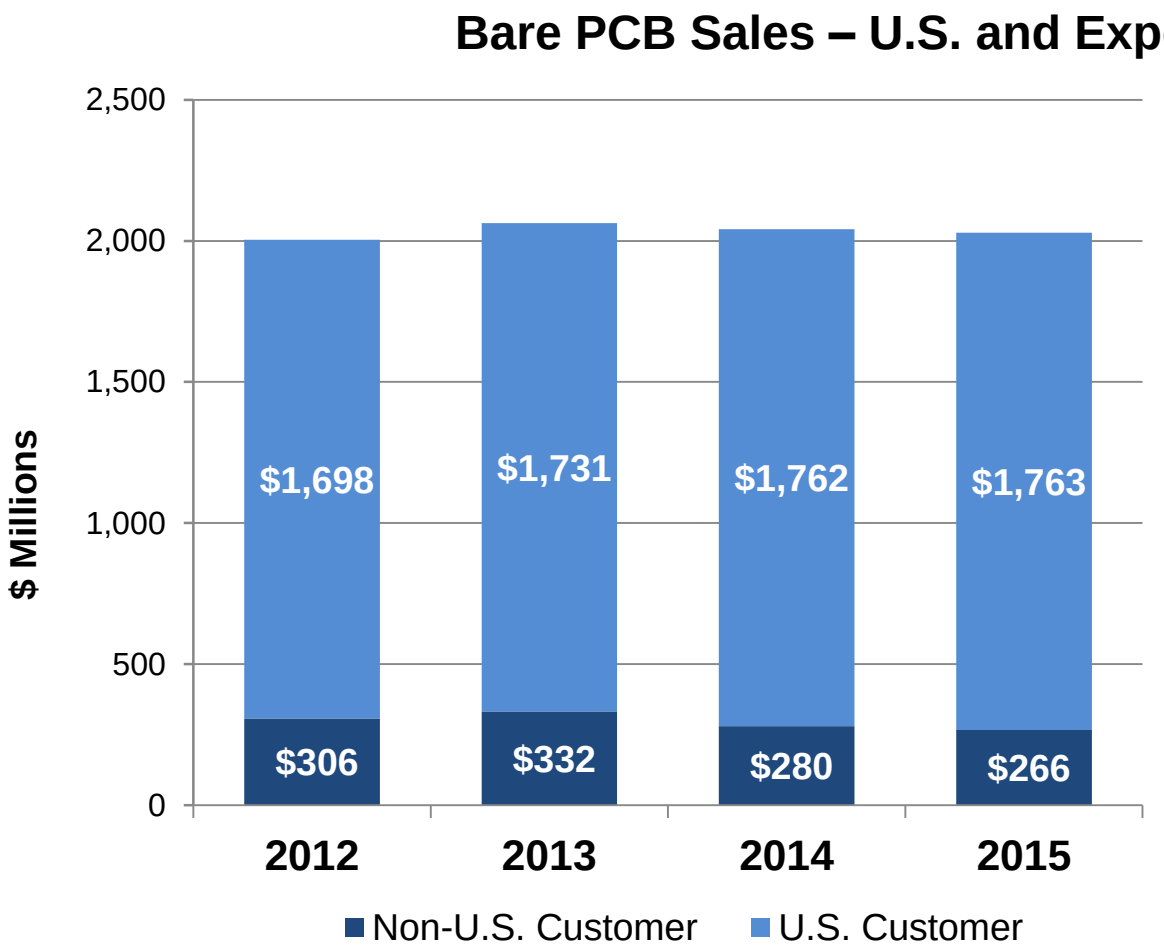


Q7

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)
U.S. and Exports



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

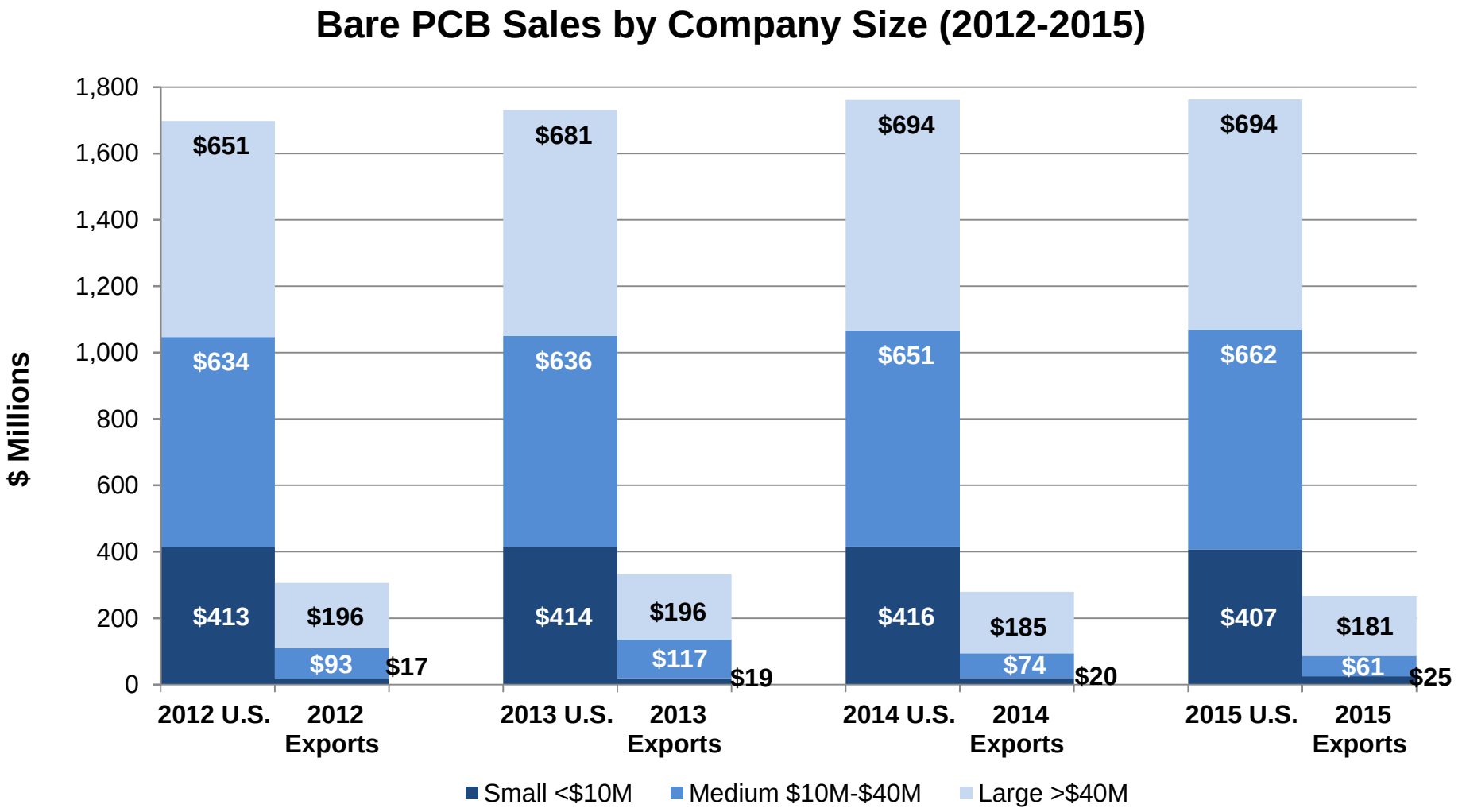
Exports **decreased** by 13 percent

Q7

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

202 respondents

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

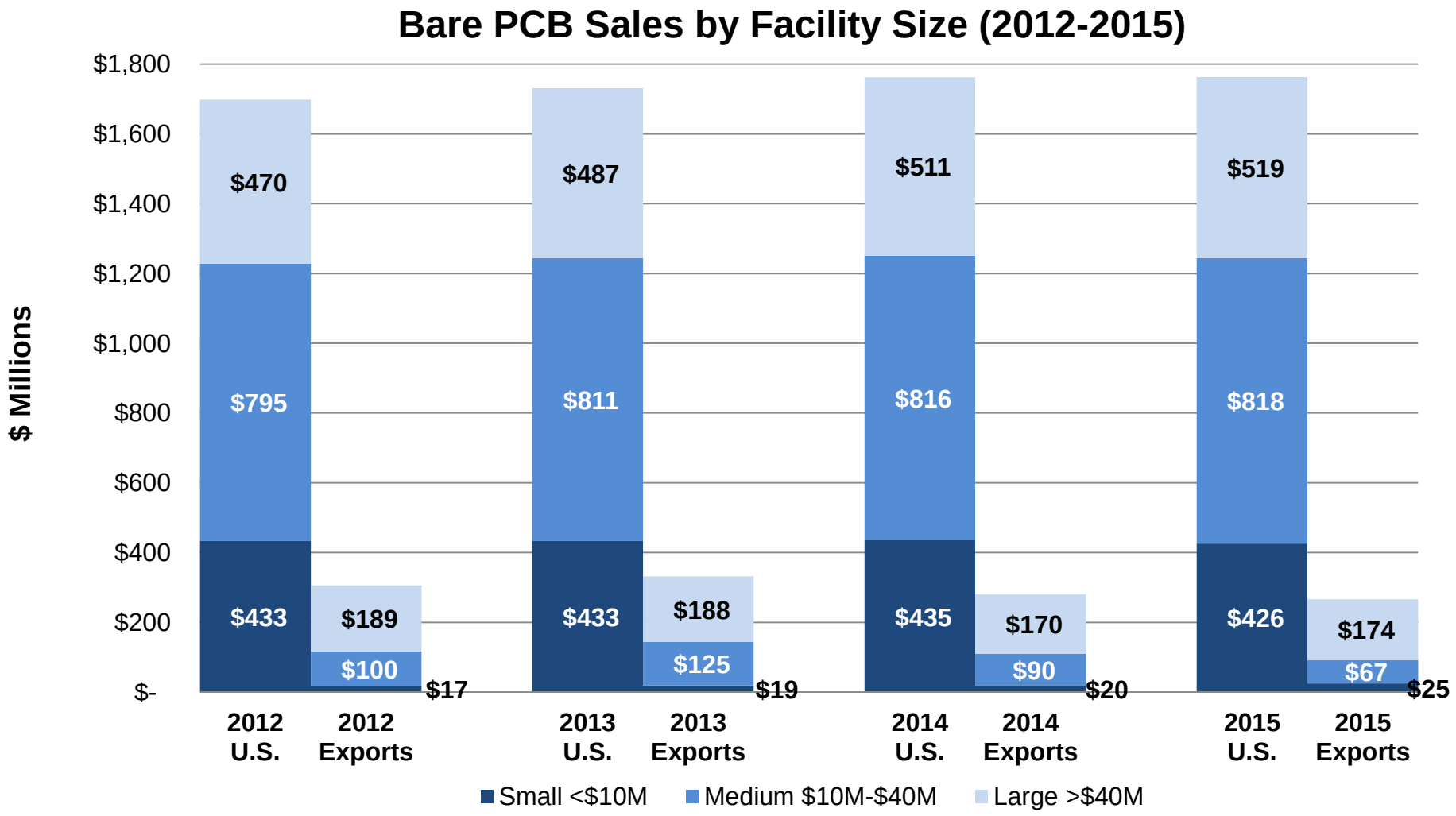


Q7

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

185 respondents

Bare PCB Facility Sales (2012-2015)
U.S. and Exports



Q7

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

202 respondents

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

Company Size	U.S. Sales % Change (2012-2015)	Export Sales % Change (2012-2015)
Large >$40M	**6.6%**	**-7.7%**
Medium $10M-$40M	**4.4%**	**-34.4%**
Small <$10M	**-1.5%**	**47.1%**

Facility Size	U.S. Sales % Change (2012-2015)	Export Sales % Change (2012-2015)
Large >$40M	**10.4%**	**-7.9%**
Medium $10M-$40M	**2.9%**	**-33%**
Small <$10M	**-1.6%**	**47%**

- 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.

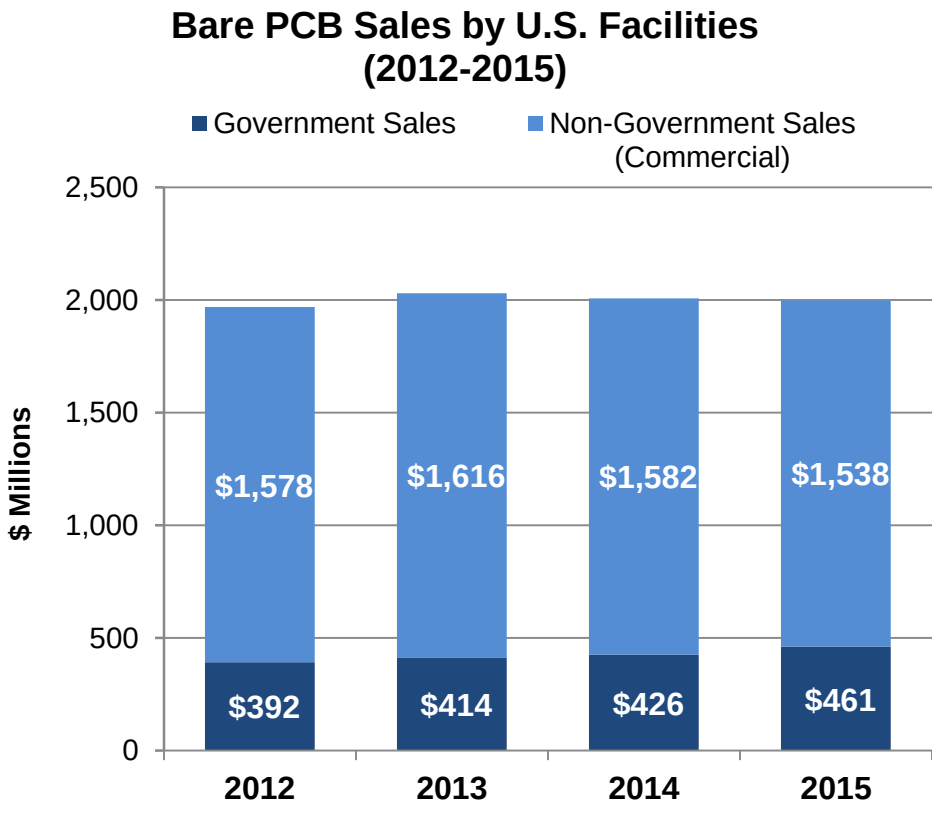
Q7

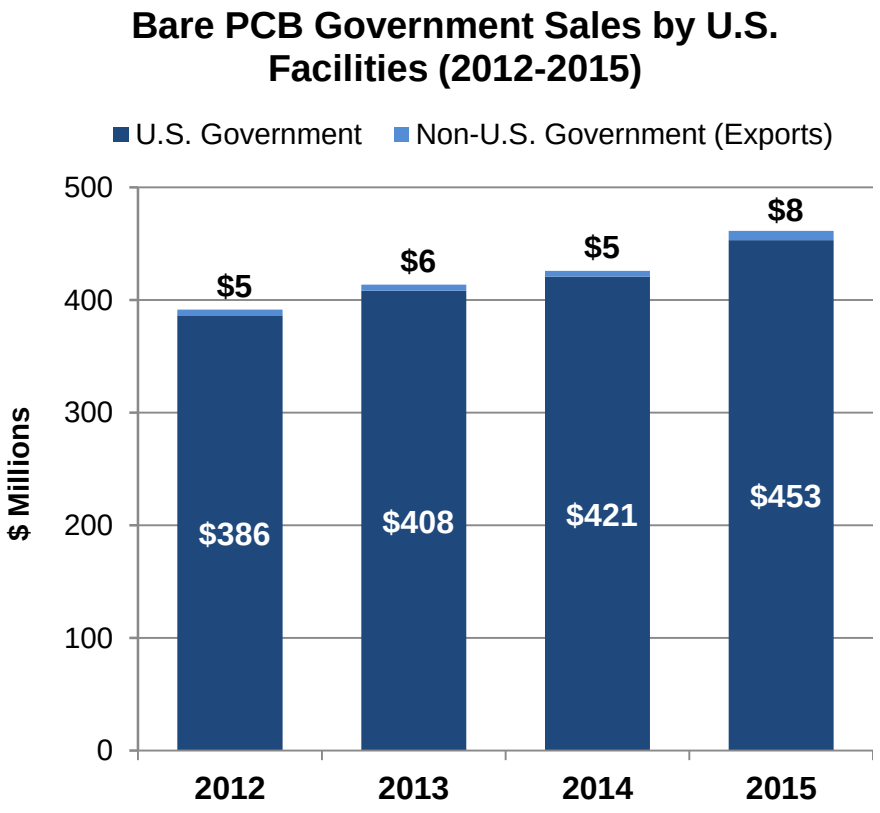
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

185 respondents

Bare PCB Sales (2012-2015)
Government vs. Non-Government Sales

- Government sales accounted for 21 percent of total Bare PCB sales during the 2012 to 2015 period.
- U.S. Government sales accounted for 99 percent of total Government sales during the 2012 to 2015 period.





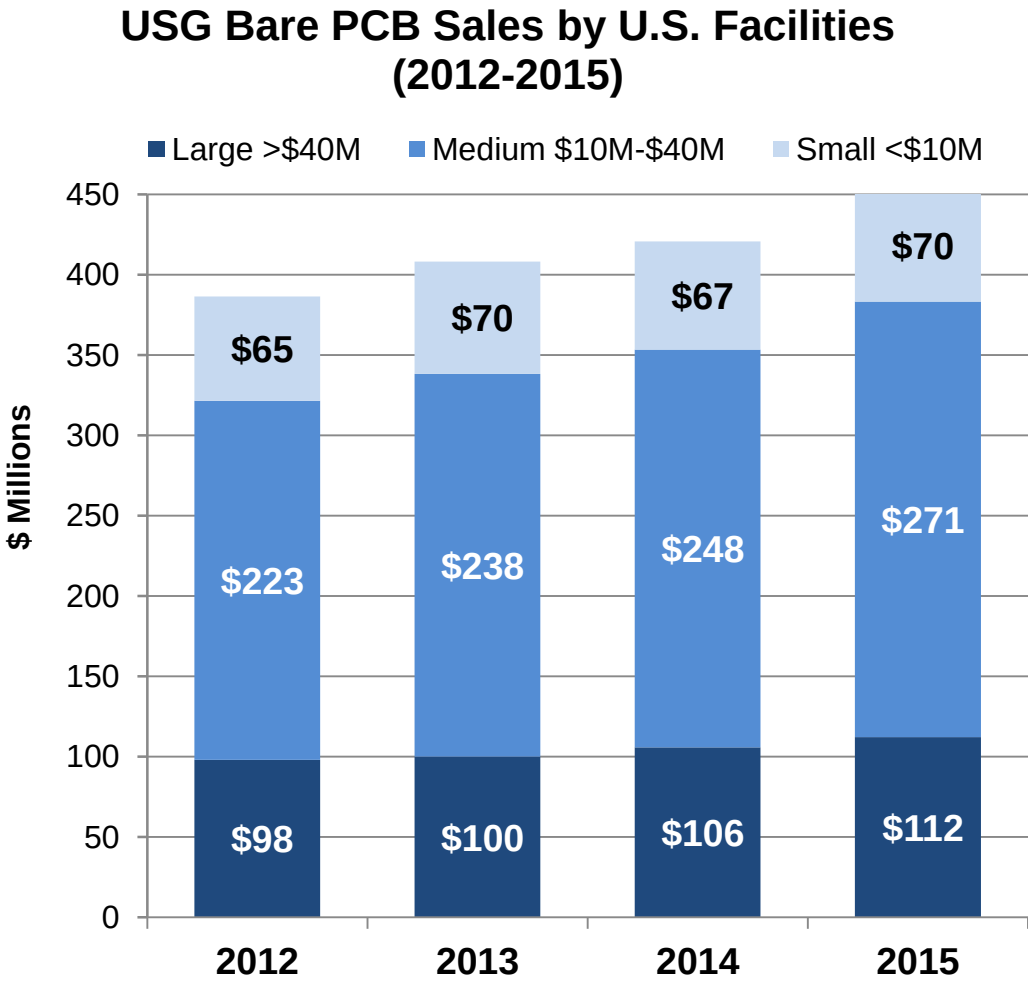
Q7

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

202 respondents

Bare PCB Sales (2012-2015)

U.S. Government



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).

Q7

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

202 respondents

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)

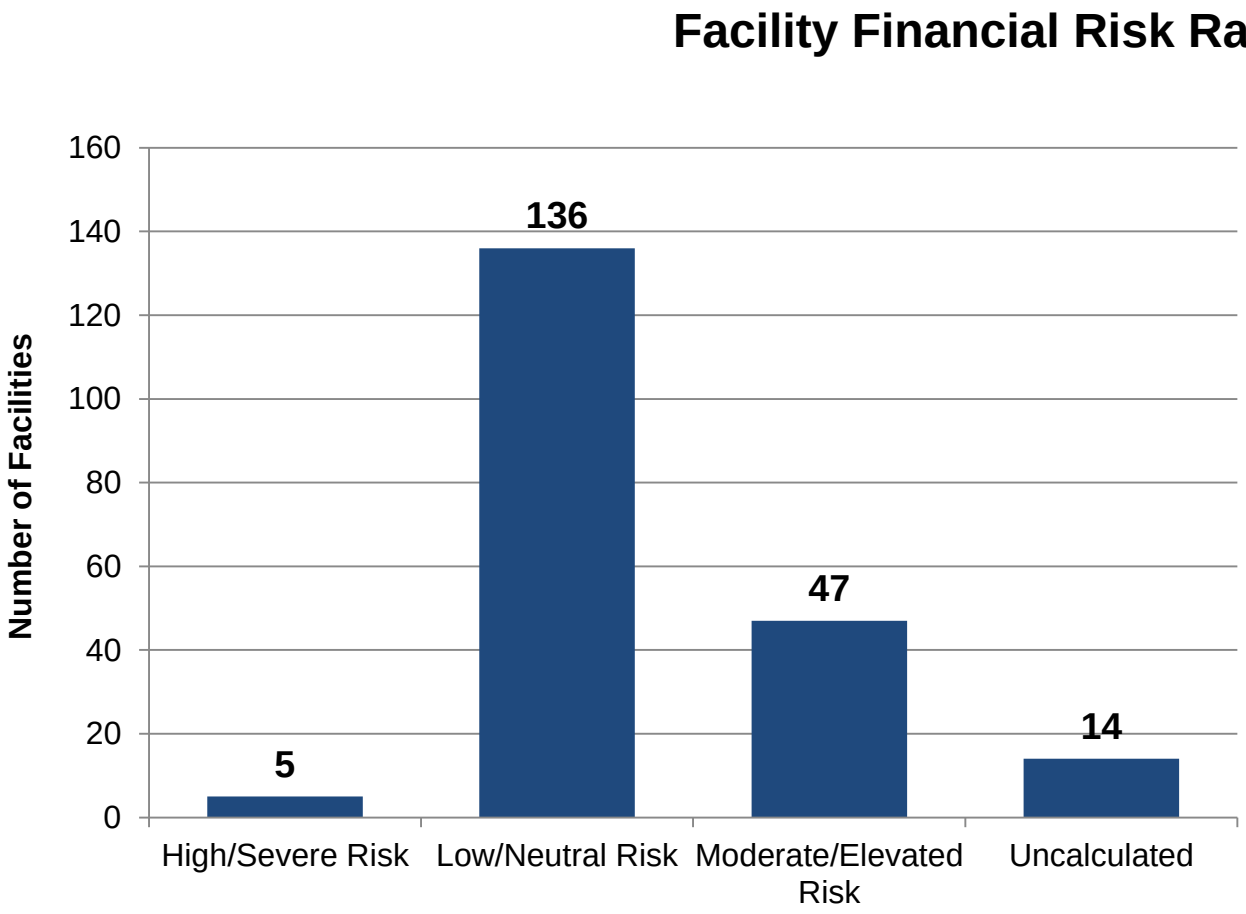
BIS survey respondents provided data on select financial accounting items, including net and operating income, assets, liabilities, and inventories.

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.

Financials

Facility Financial Risk Ratings (2012-2015)



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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.

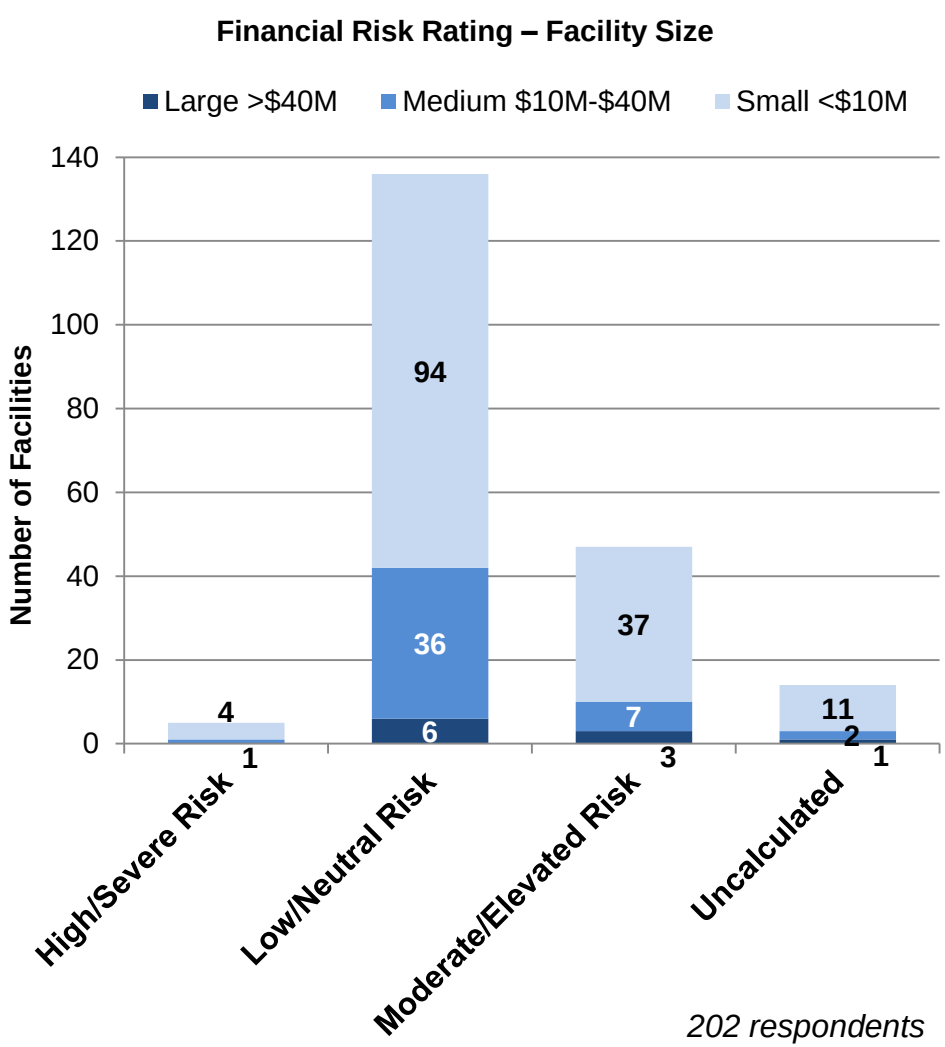
Q8

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

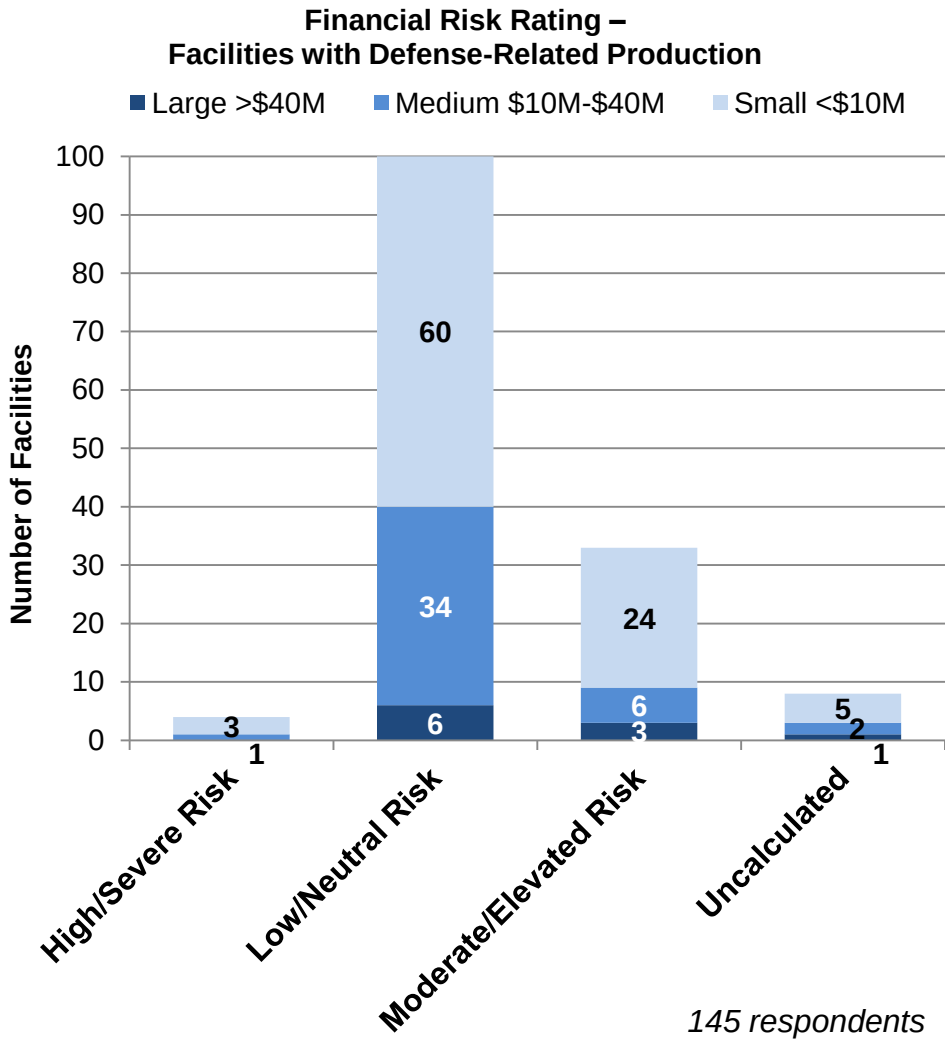
202 respondents

Financials

Financial Risk Ratings By Facility Size (2012-2015)



202 respondents



145 respondents

Q8

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

Financials

Financial Risk Ratings By Facility Size (2012-2015)

Financial Risk Rating Facility Size

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

Facility Financial Risk Score	Large >$40M	Medium $10M-$40M	Small <$10M	**Total**
High/Severe Risk	0	1	4	**5**
Low/Neutral Risk	6	36	94	**136**
Moderate/Elevated Risk	3	7	37	**47**
Uncalculated	1	2	11	**14**
Total	**10**	**46**	**146**	**202**

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

Facility Financial Risk Score	Large >$40M	Medium $10M-$40M	Small <$10M	**Total**
High/Severe Risk	0	1	3	**4**
Low/Neutral Risk	6	34	60	**100**
Moderate/Elevated Risk	3	6	24	**33**
Uncalculated	1	2	5	**8**
Total	**10**	**43**	**92**	**145**

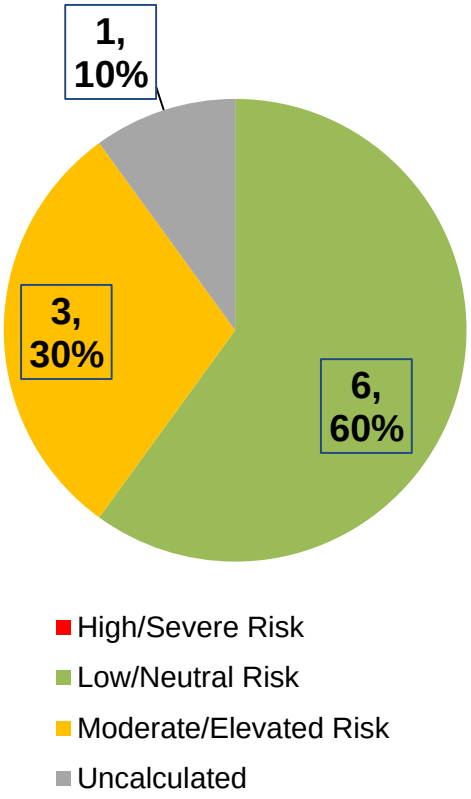
Q8

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

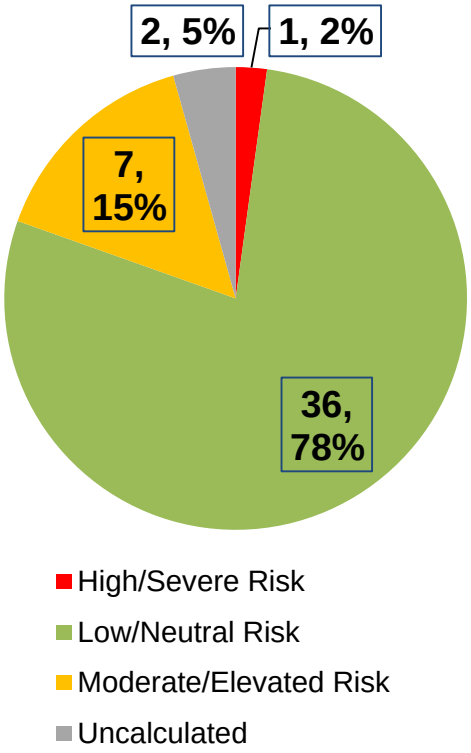
Financials

Financial Risk Ratings by Facility Size (2012-2015)

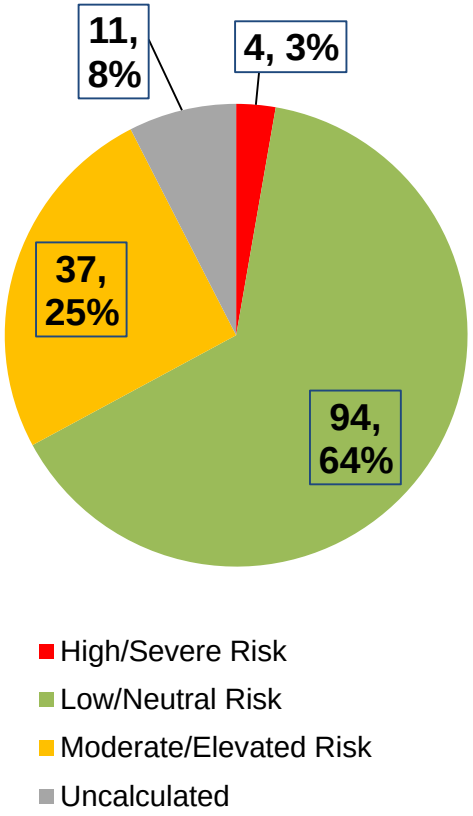
Financial Risk Rating – Large Facilities (10)



Financial Risk Rating – Medium Facilities (46)



Financial Risk Rating – Small Facilities (146)



Q8

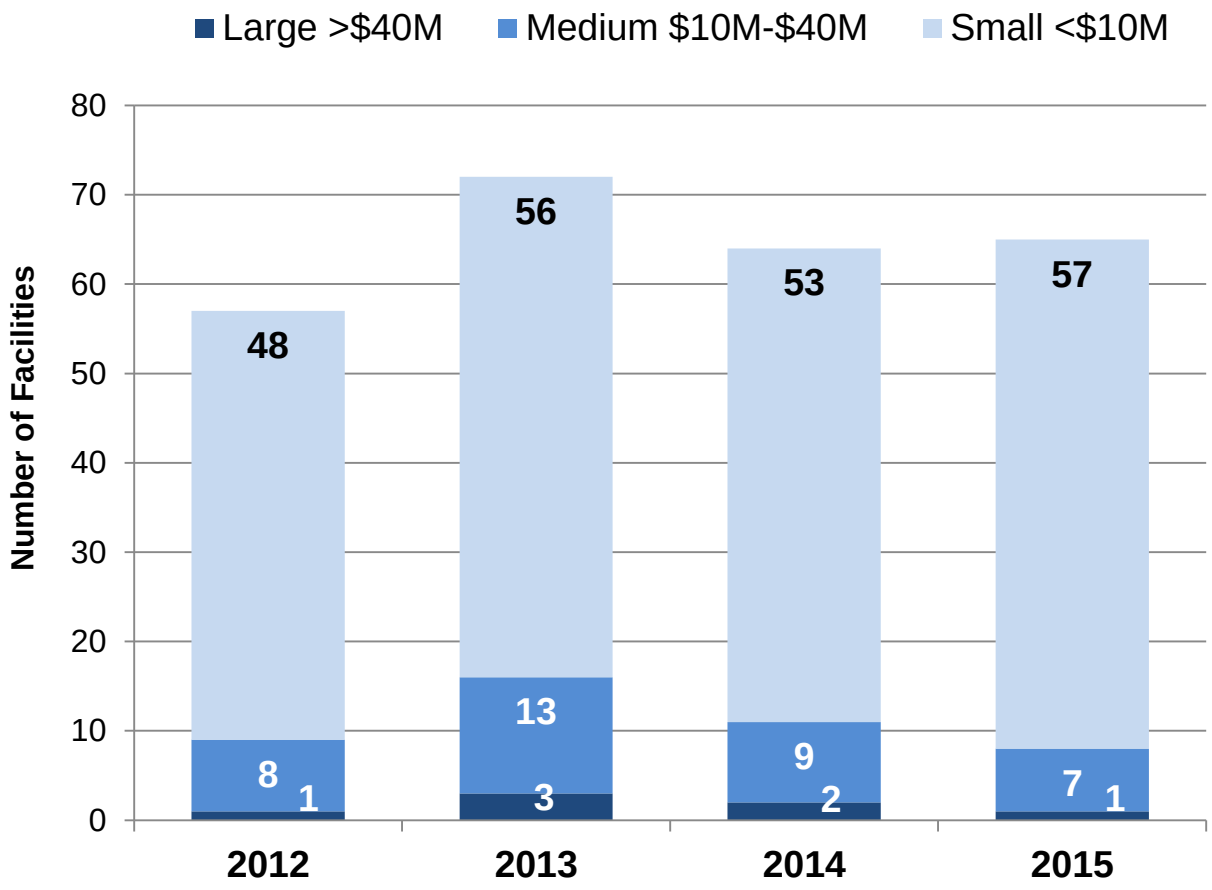
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Financials

Negative Net Income (2012-2015)

Facilities Reporting Negative Net Income (2012-2015)



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.

Q8

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

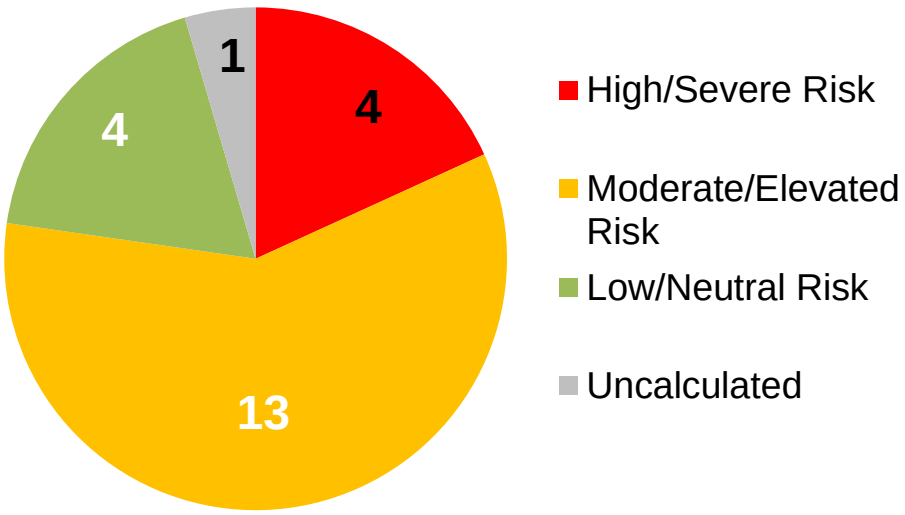
202 respondents

Financials

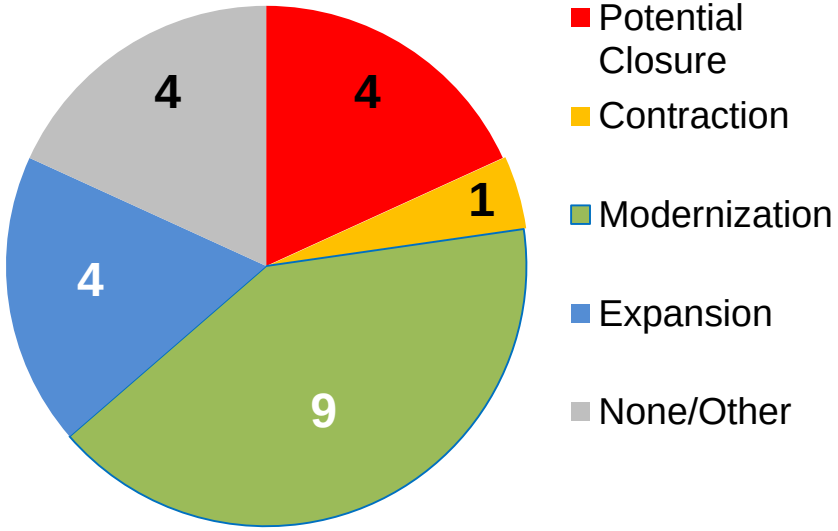
Facilities Operating at Net Loss (2012-2015)

- **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



Changes Expected 2016-2020



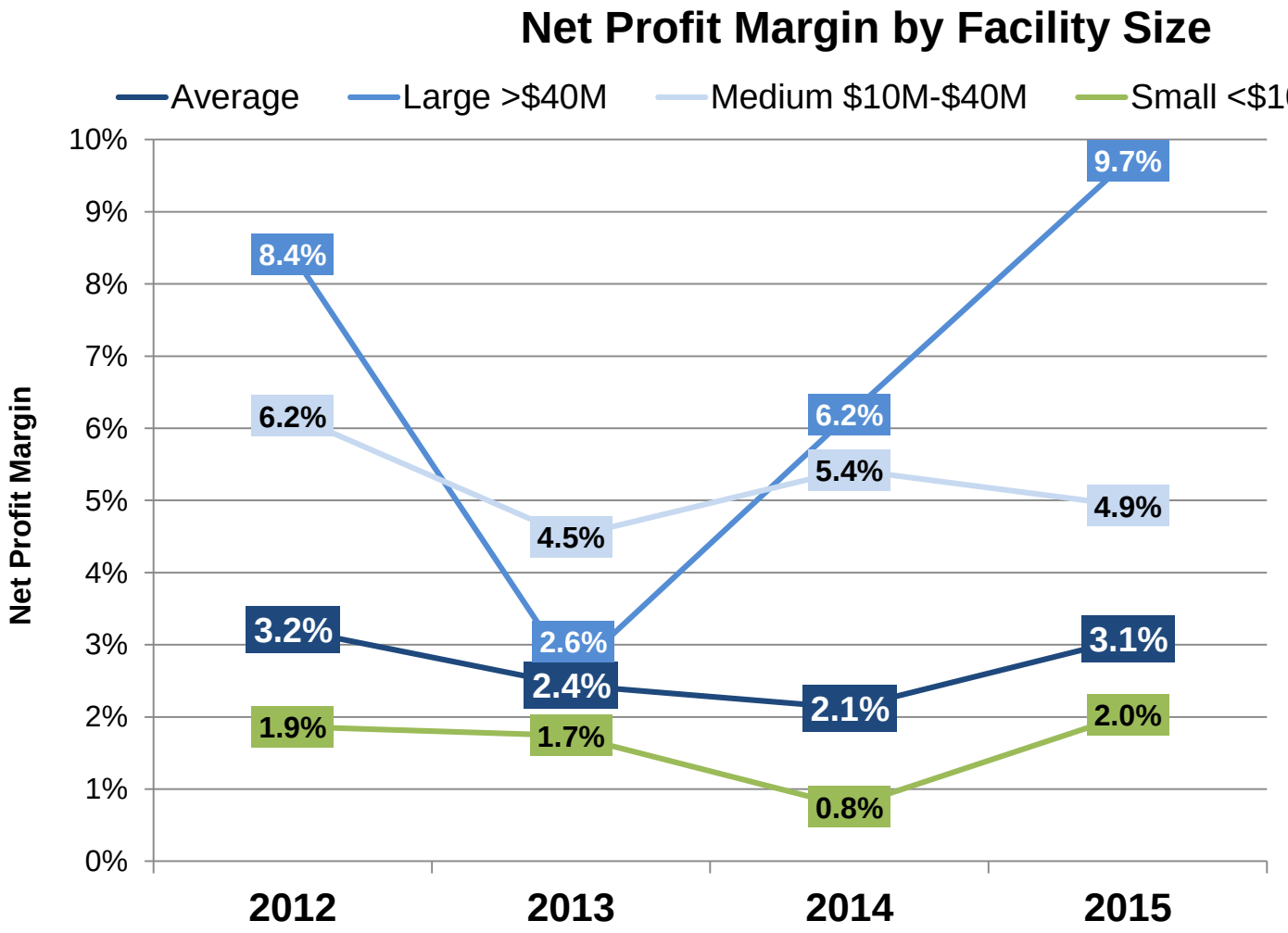
Q8

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)



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

Q8

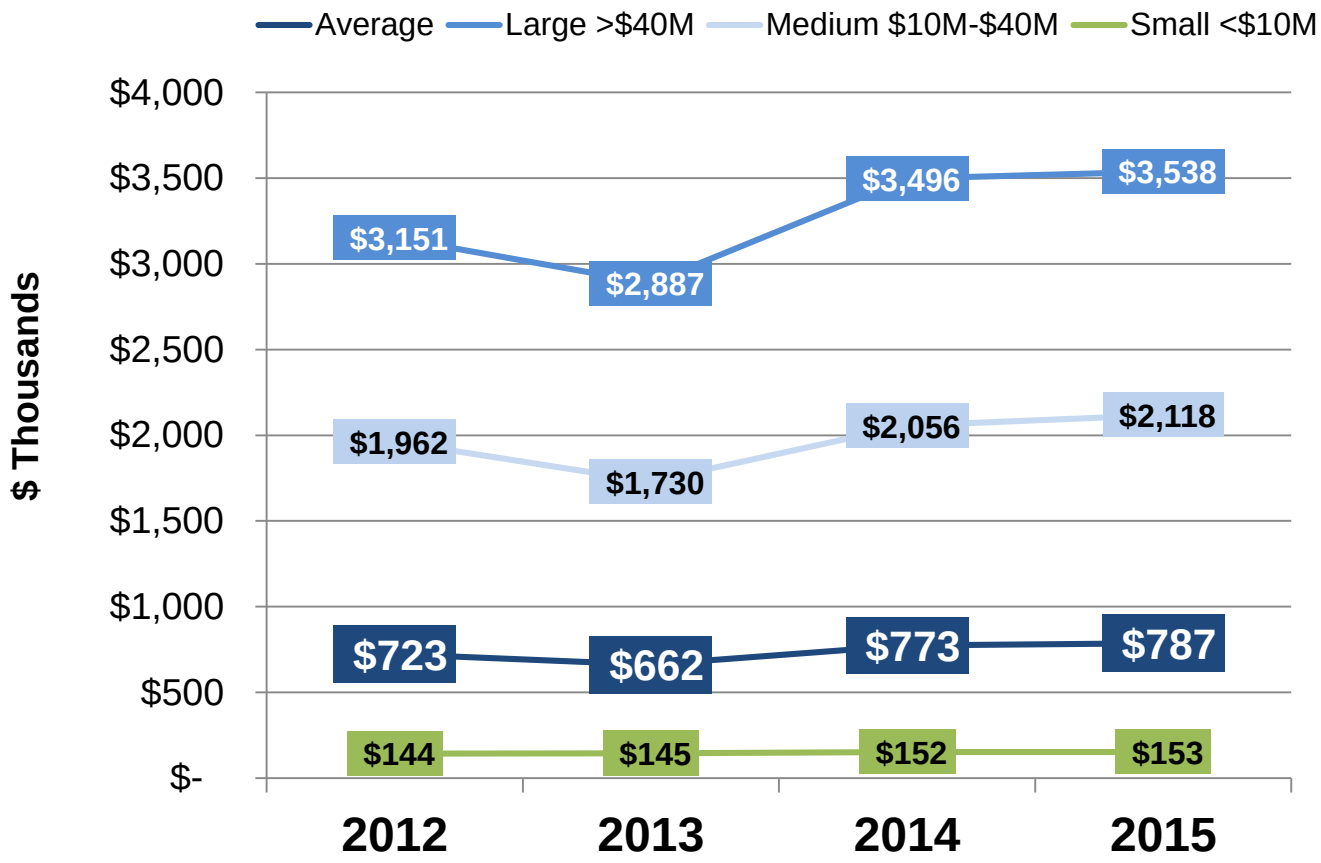
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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.

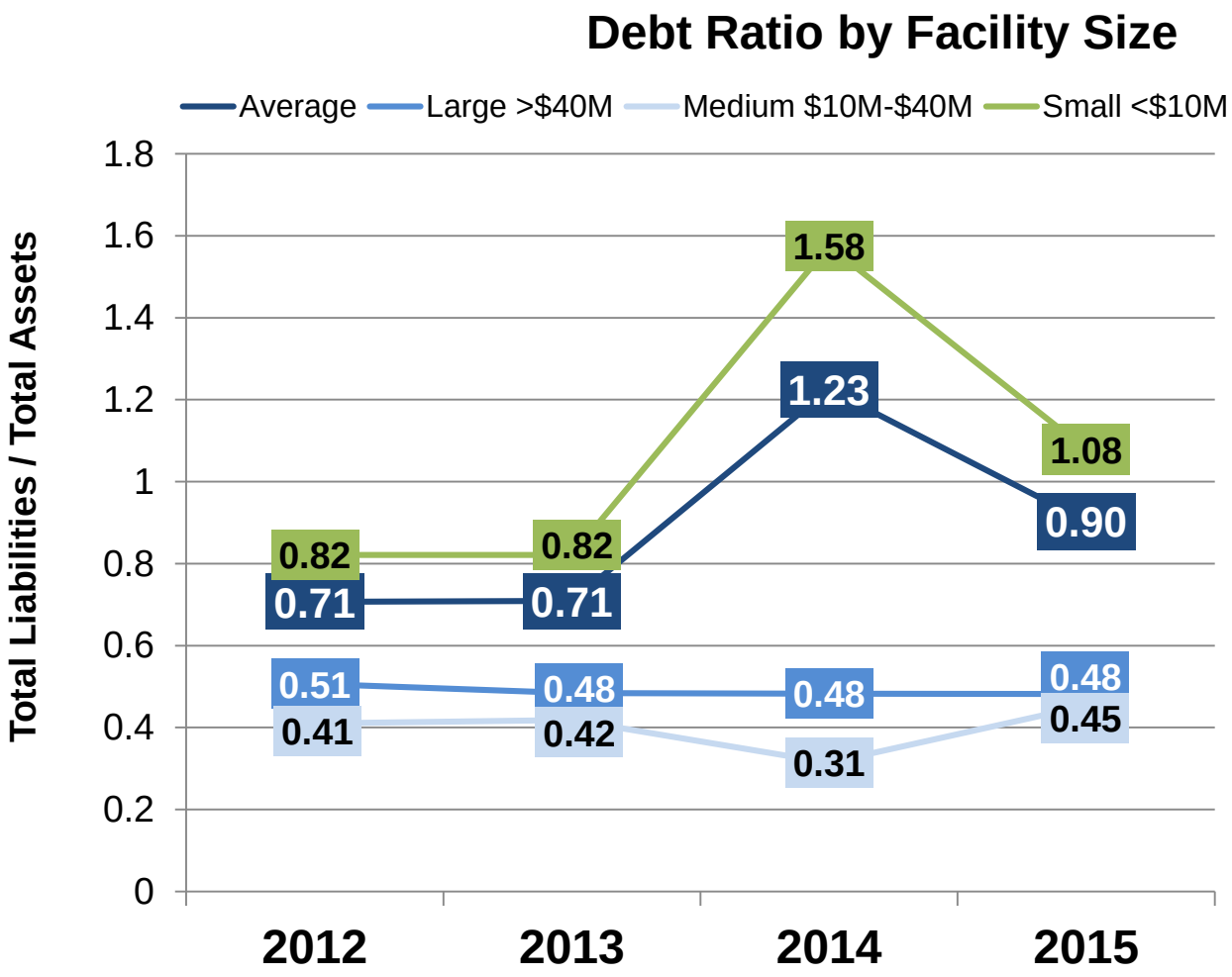
Q8

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

202 respondents

Financials

Debt Ratio (2012-2015)



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.

Debt Ratio
=
Total Liabilities/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.

Q8

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

202 respondents

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)

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%

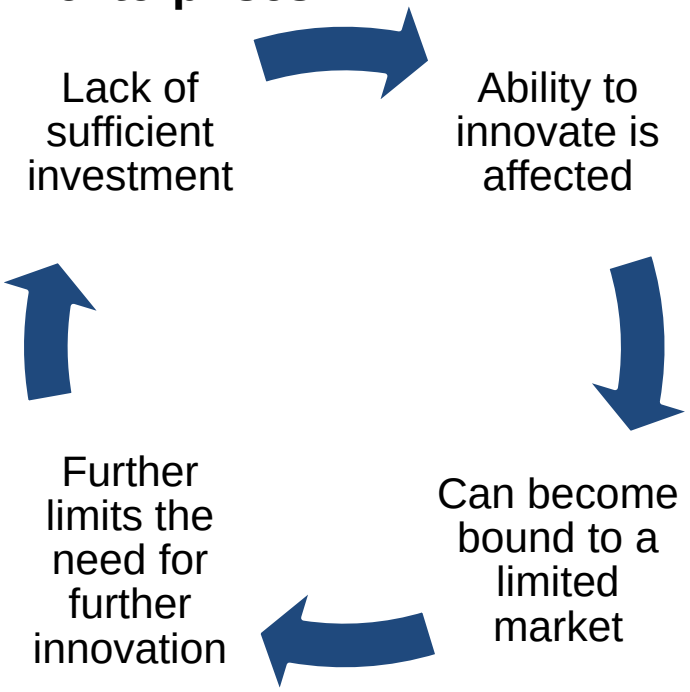
Only 38 out of 185 companies reported conducting R&D:
- Large - 4 (80%)
- Medium - 14 (39%)
- Small - 20 (13%)

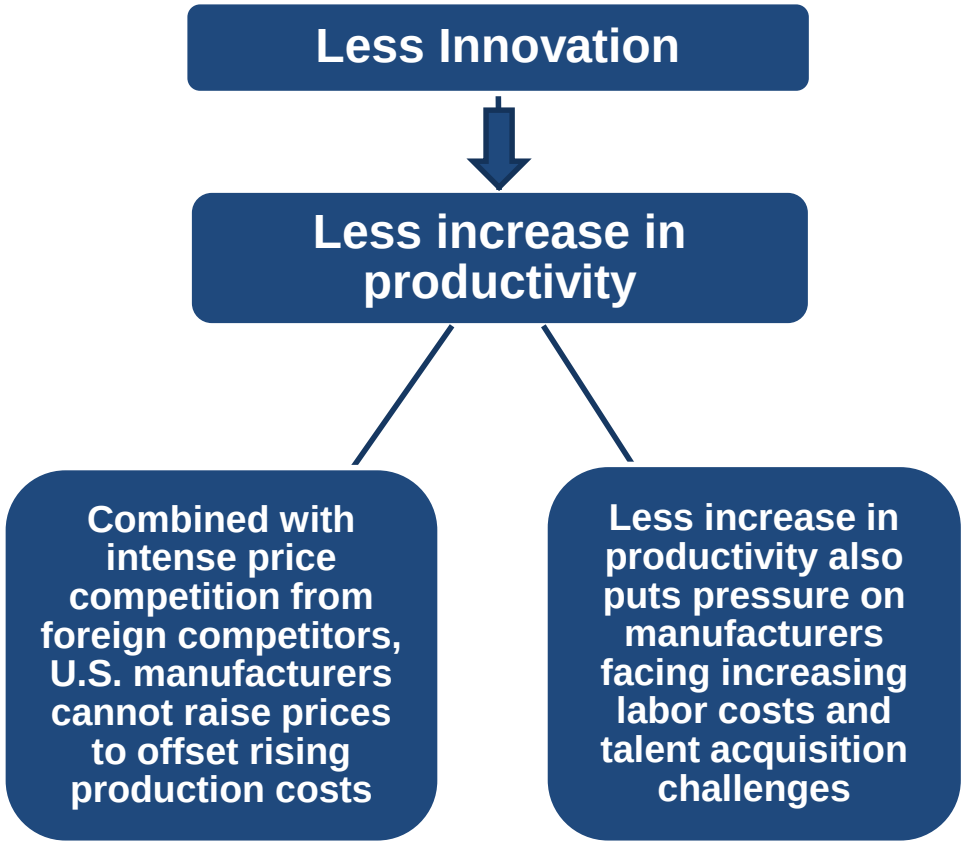
Source: U.S. Department of Commerce, Bureau of Industry and Security
'U.S. Bare Printed Circuit Board Industry Assessment – 2017

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:





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.

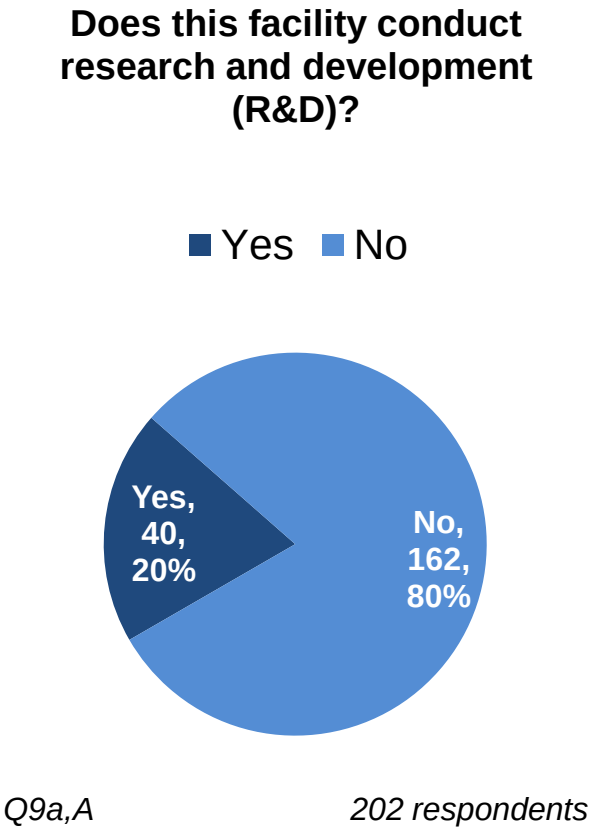
- Need for U.S. PCB Industry partnership and collaboration efforts (consortium) to conduct R&D?
  - Possible partners – DARPA, NIST, iNEMI, Universities, others?
  - Increase investments in basic technology, product R&D, and process R&D.
  - Creation of tax incentives, rebates or credits for DoD suppliers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

Research & Development (2015)

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%)

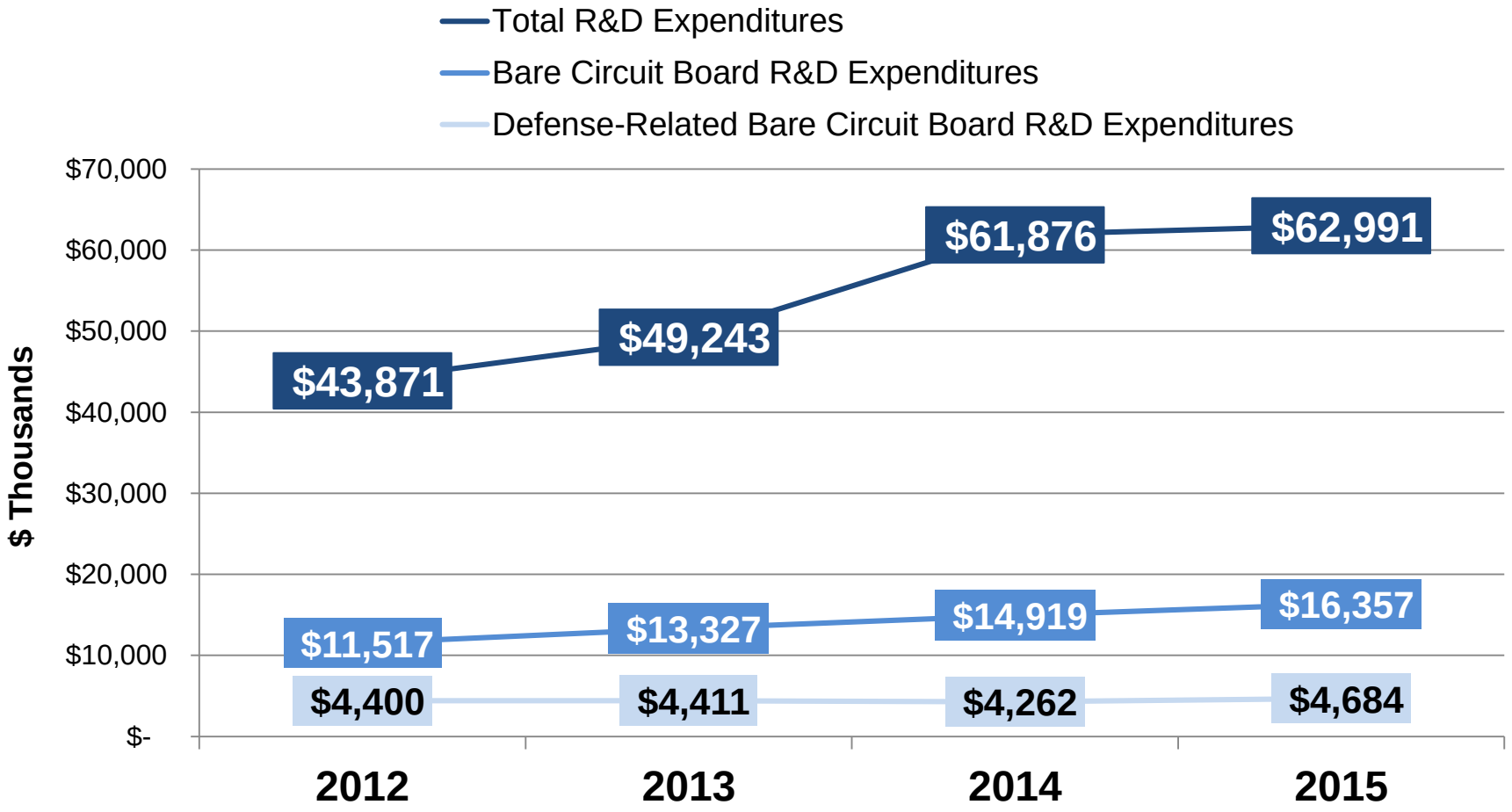


Q9a,A *202 respondents*

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

Research & Development

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



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

Q9a,B

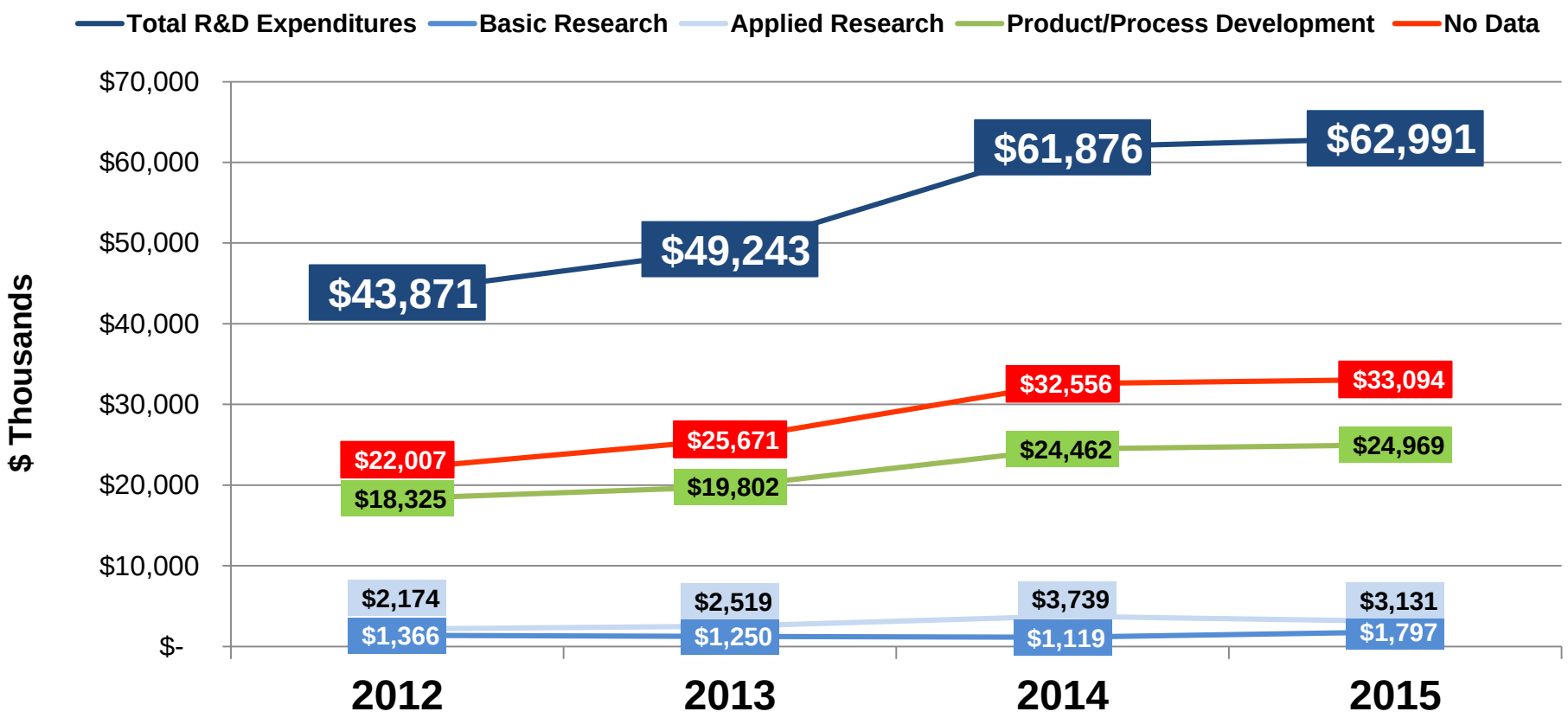
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

38 respondents

Research & Development

Types of Expenditures

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



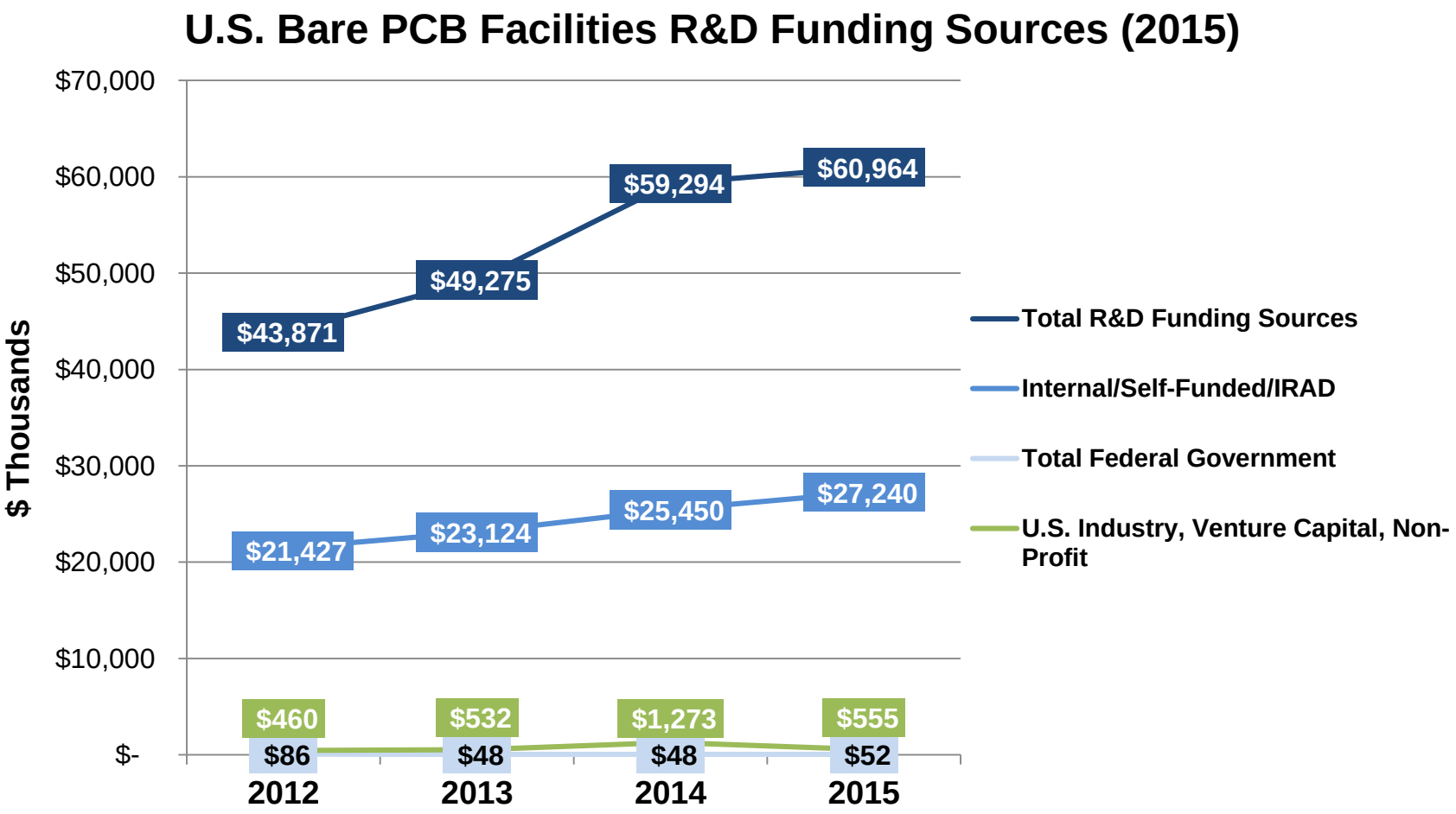
*Note: R&D expenditures for one large company are not included
**No data refers to R&D expenditures not identified by type. Many respondents were not able to report R&D expenditures with that level of detail.

Q9a,B

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

38 respondents

Research and Development
Funding Sources



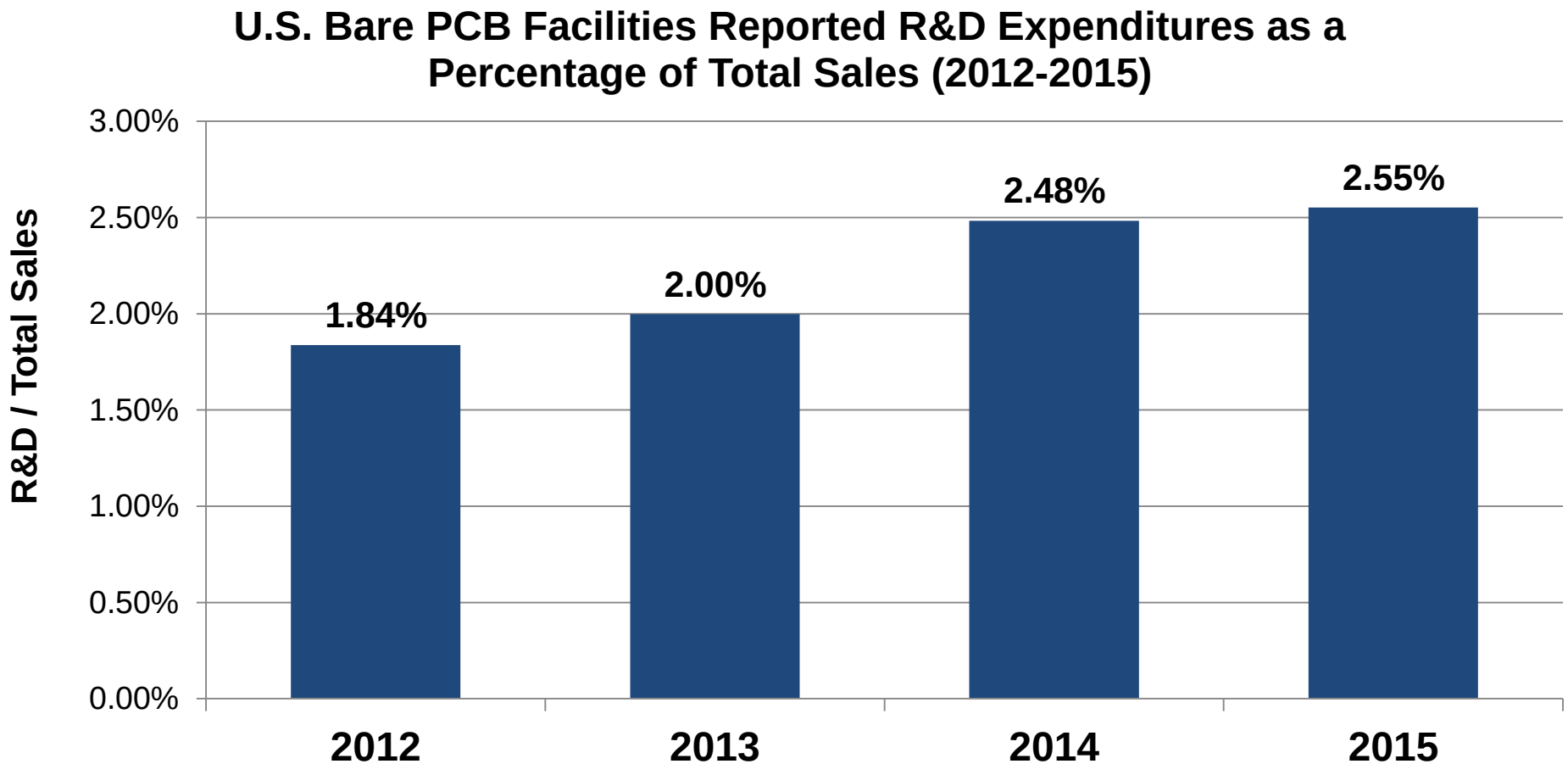
*Note: R&D expenditures for one large company are not included

Q9a,C

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

38 respondents

Research and Development
Percentage of Total Sales



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

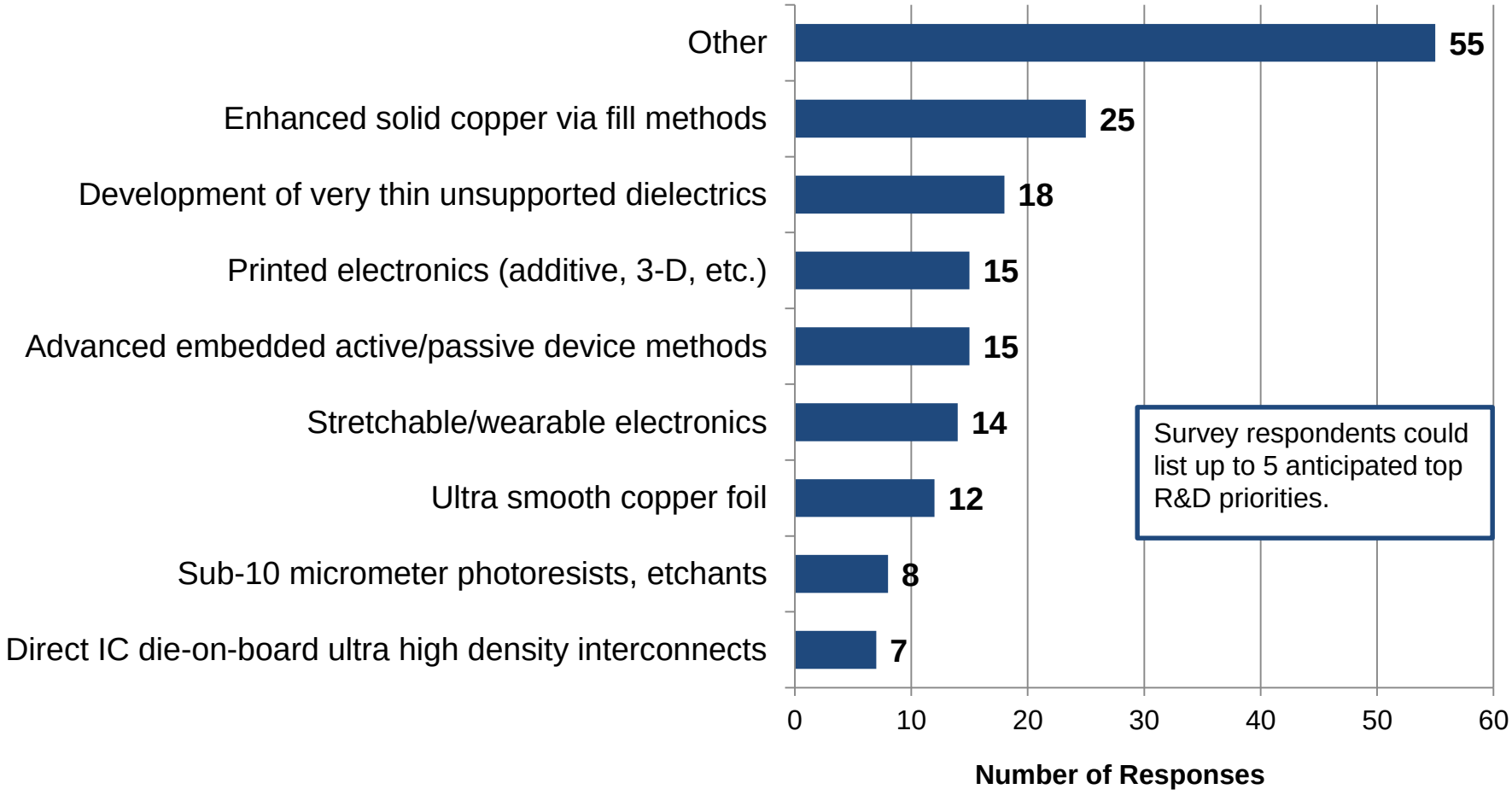
Q9a,B1

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)



Q9b,A

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

59 respondents

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

Q9b,A

59 respondents

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

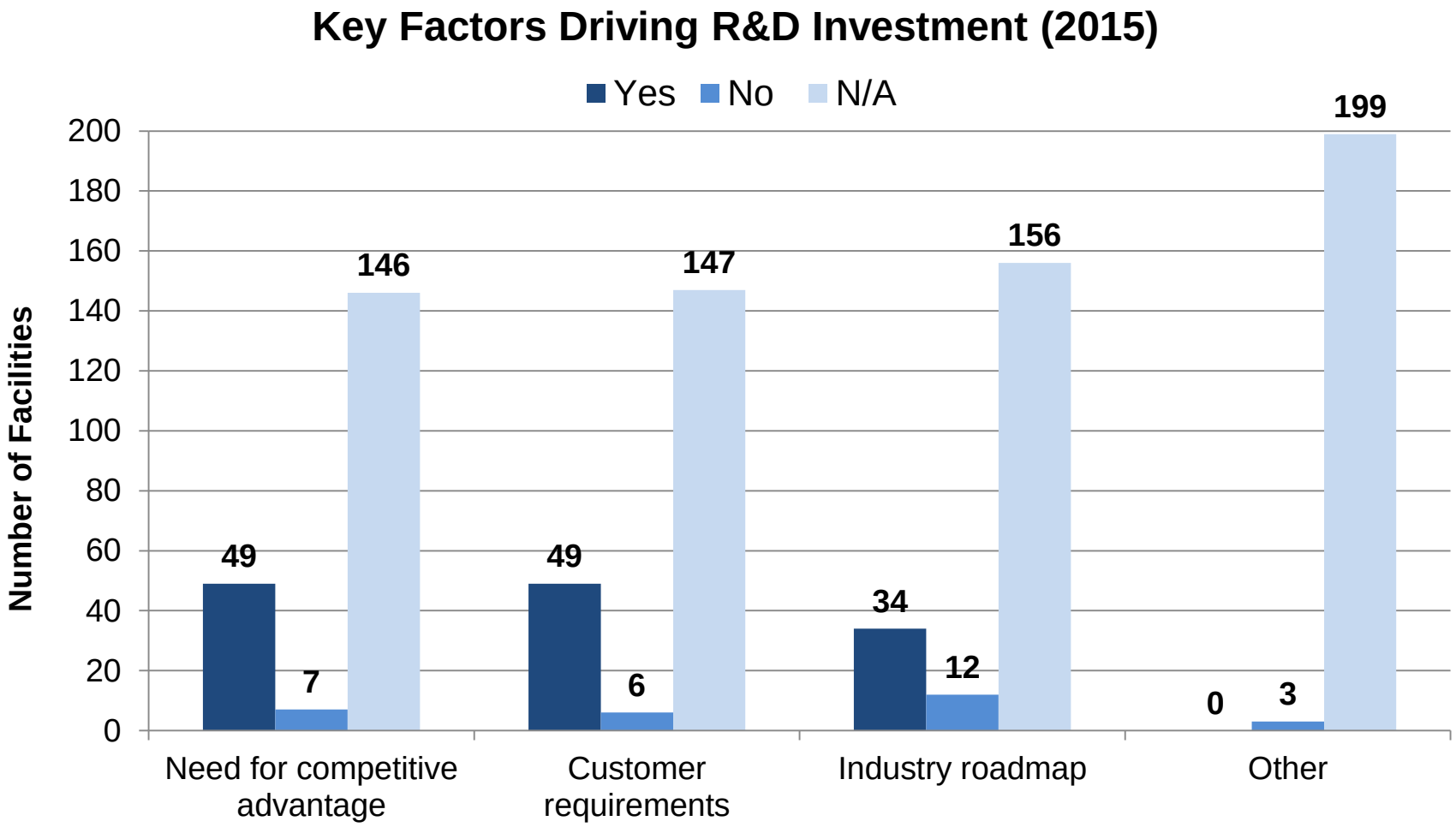
Enhanced solid copper via fill methods	• Copper fill and high aspect ratio needs • Reduce cycle-time, expand aspect ratio capability • Need to continue to refine this process and improve throughput. • Plan to add metal and epoxy via fill capabilities • Copper via fill is demanded in today's market and 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
Development of very thin unsupported dielectrics	• 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.
Advanced embedded active/passive device methods	• 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
Stretchable/ wearable electronics	• Addition of metal and epoxy via fill capabilities • Flex and rigid-flex product • Flex circuits is an area to investigate • Prototypes
Ultra smooth copper foil	• Stacked/staggered via configurations • RF demand to improve circuit loss • High speed designs
Sub-10 micrometer photoresists, etchants	• 2 mil cores and lower
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.

Q9b,A

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

59 respondents

Research & Development
Investment Factors



Q9b,B

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

202 respondents

Research & Development

Key Factors Driving Investment: Industry Comments

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"

Q9b,B

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

202 respondents

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"

Q9b,B

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

202 respondents

Research & Development

Key Factors Driving Investment: Industry Comments

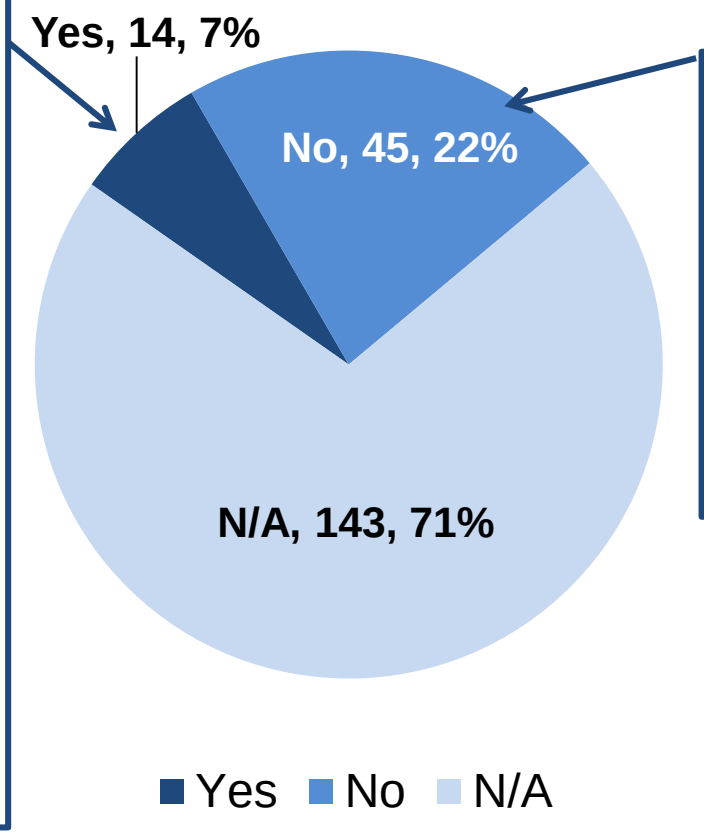
Industry roadmap:

- "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"

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?

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"

Q9b,C

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

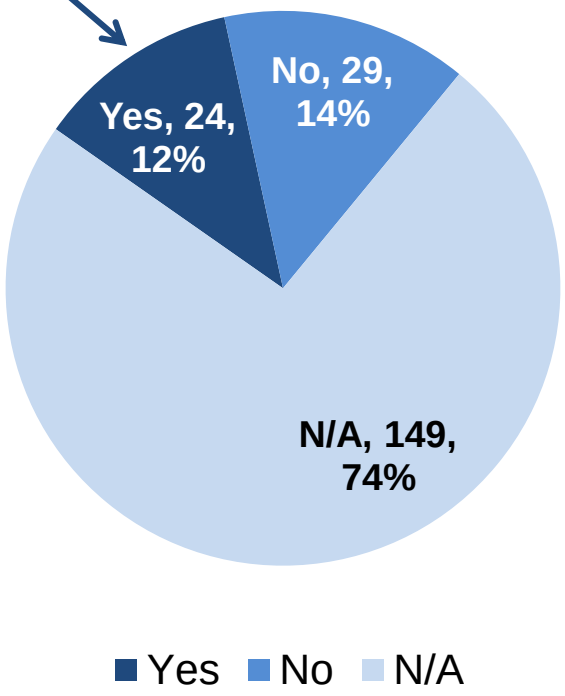
202 respondents

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?



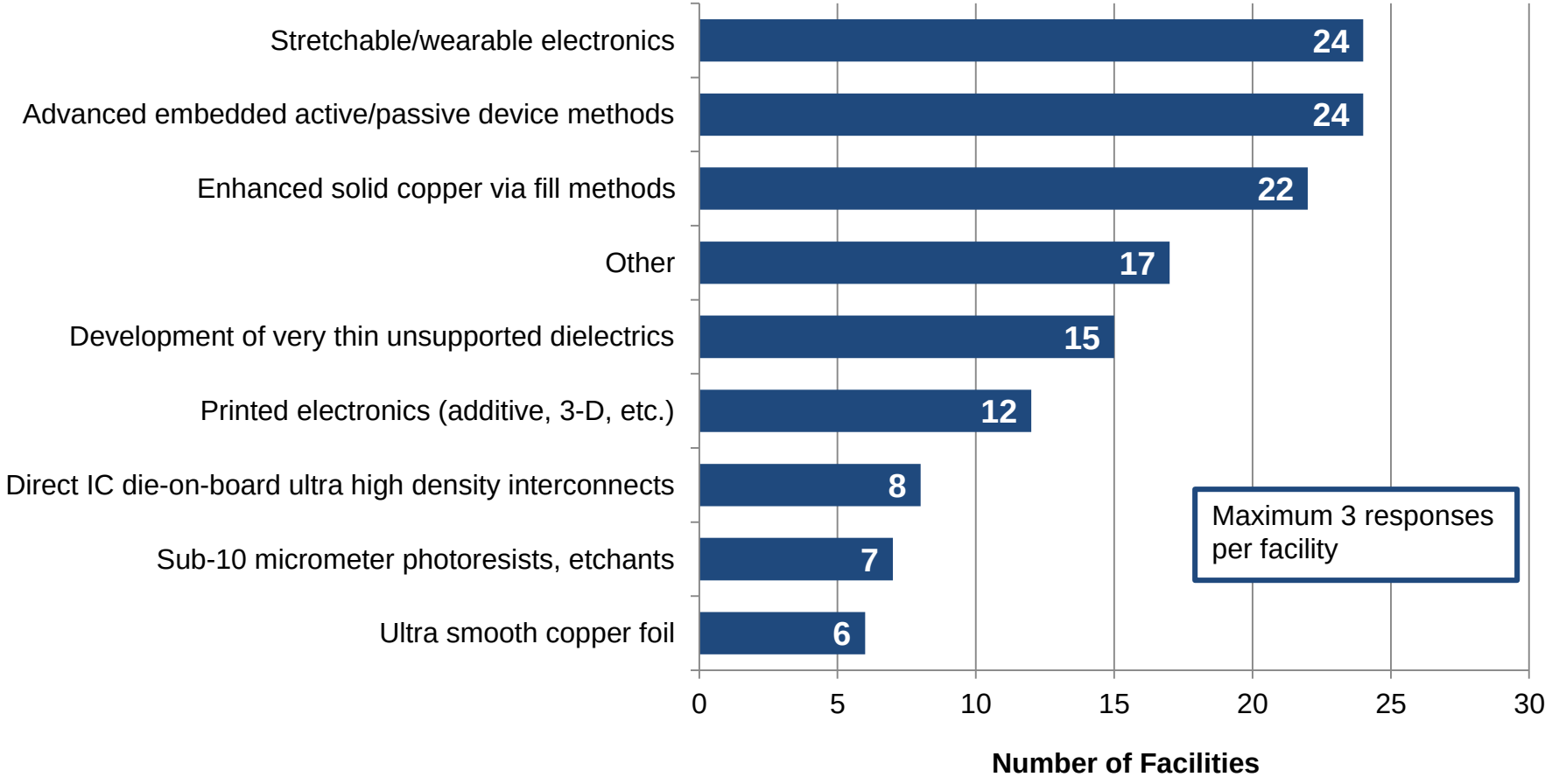
Q9b,D

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

202 respondents

Research & Development
Technology Priorities for DoD (2015)

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



Q9b,E

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

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 a 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"

Q9b,E

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

53 respondents

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"

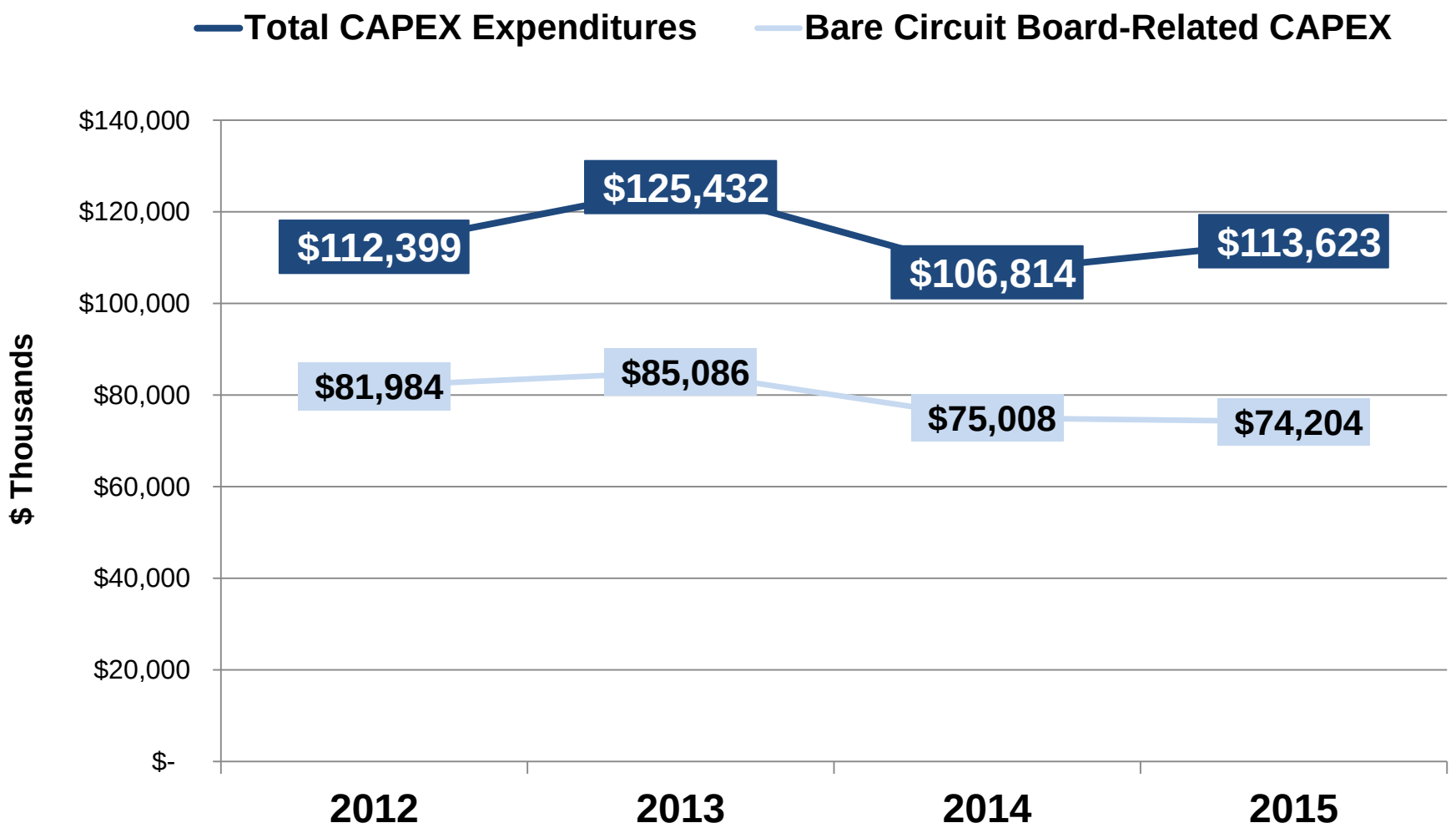
Stretchable/wearable electronics
- "Advance the use of printable material on polyimide"
- "Forming and/or embedding circuits as part for clothing, pack, helmet, etc.…will lighten war fighter load while improving mission assurance/traceability/communications/etc."

Q9b,E

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

53 respondents

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

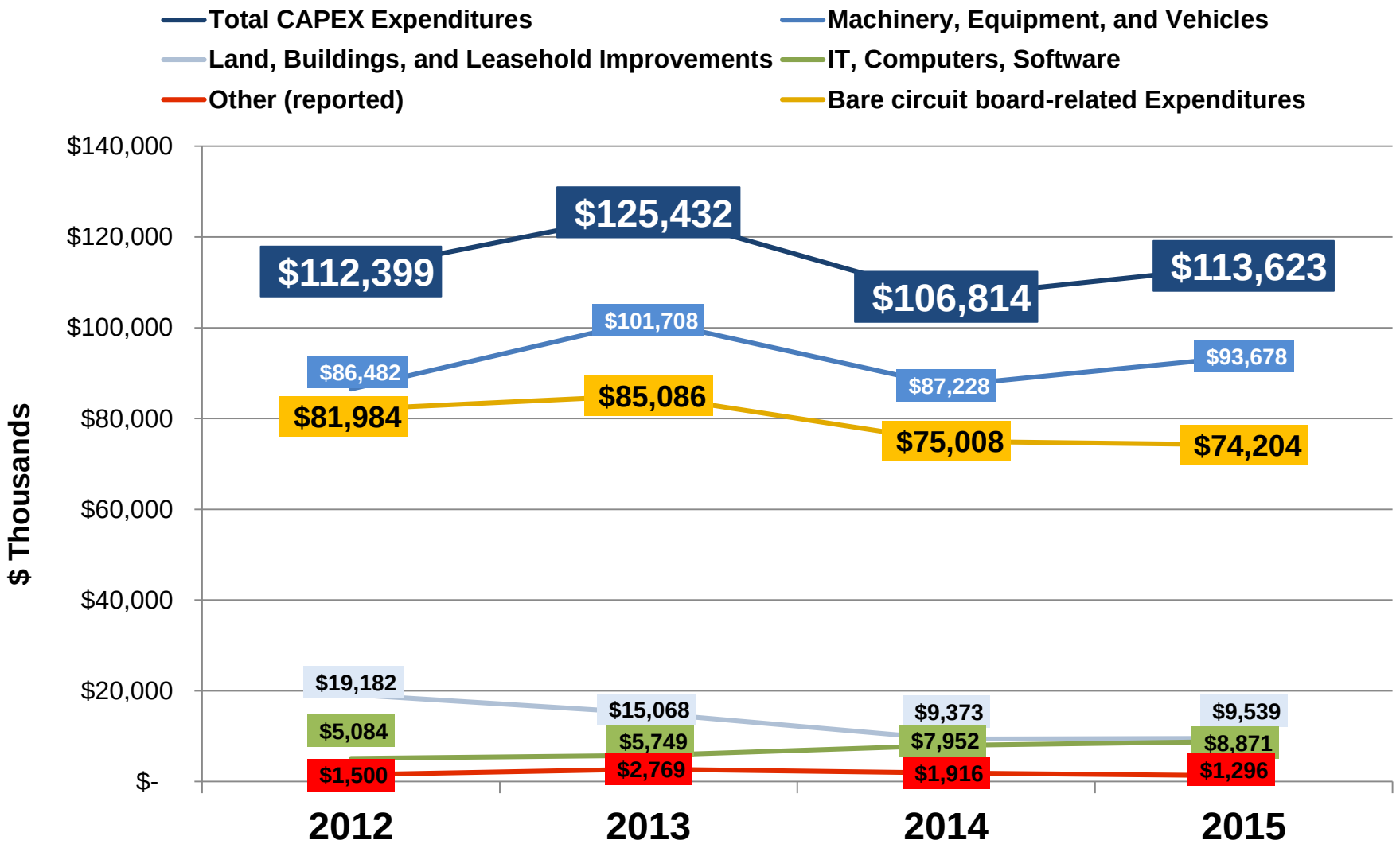


Q10A

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 Capital Expenditures (2012-2015)



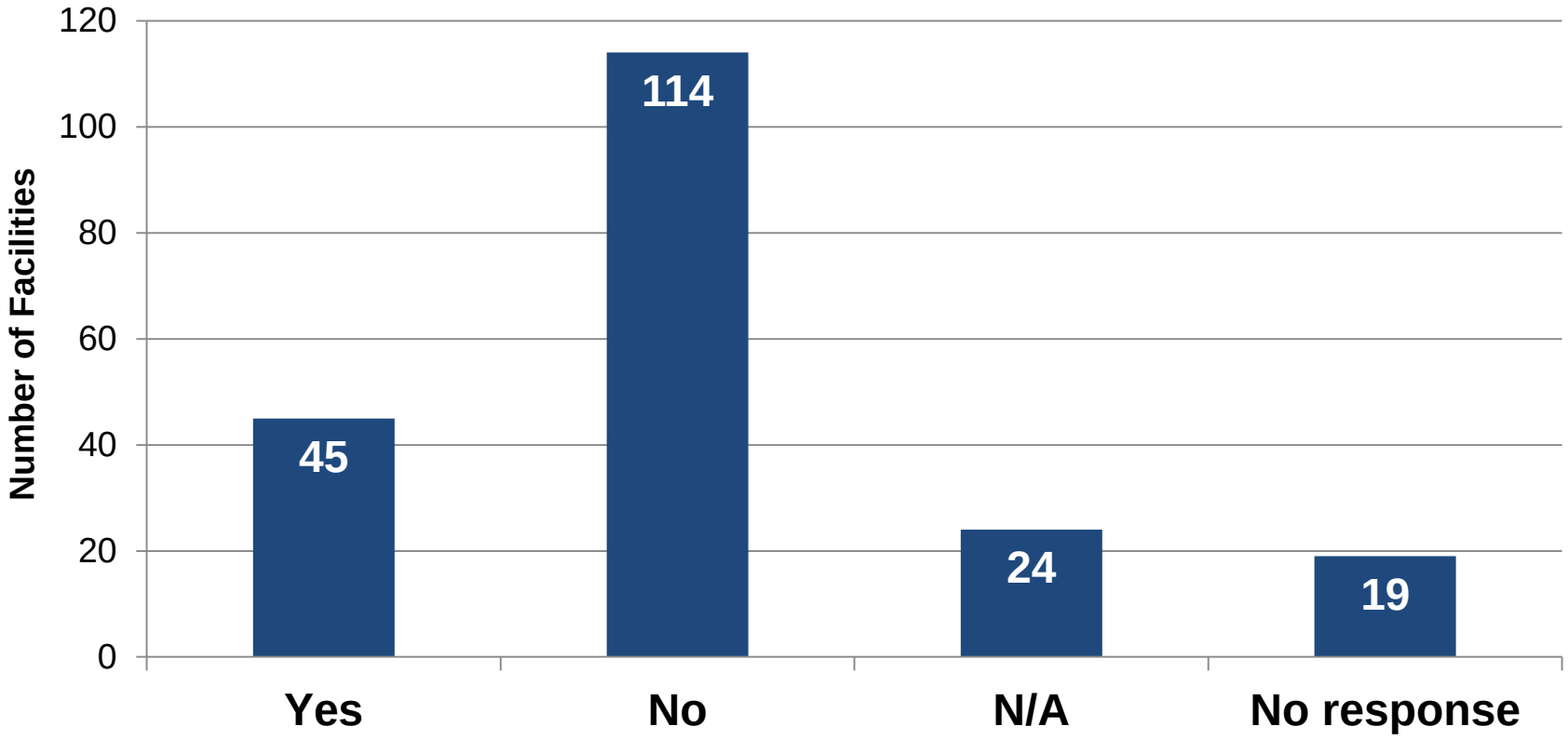
Q10A

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

202 respondents

Capital Expenditures
USG Defense Spending Impact

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



Q10B

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

202 respondents

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"

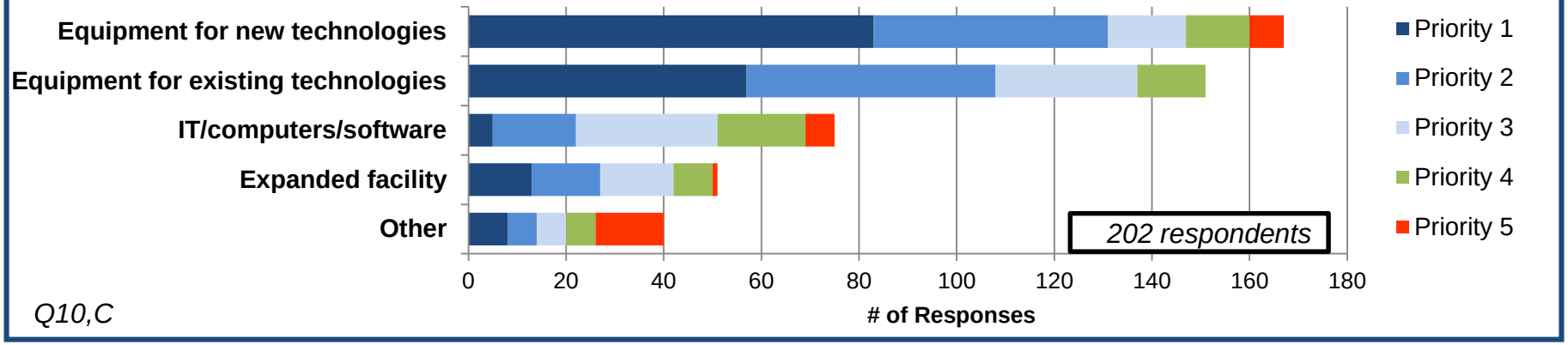
Q10B

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

202 respondents

CAPEX: Top Priorities for U.S. PCB Manufacturers

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



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

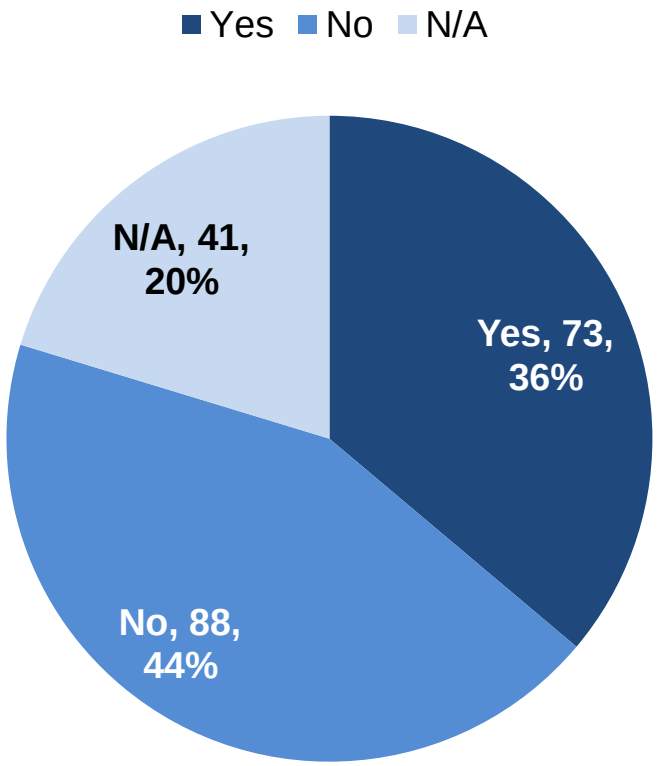
- Aging workforce and upcoming retirement is also an industry challenge.
  - 13% of technical staff (scientists, engineers, R&D staff) expected to retire by 2020.

- 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

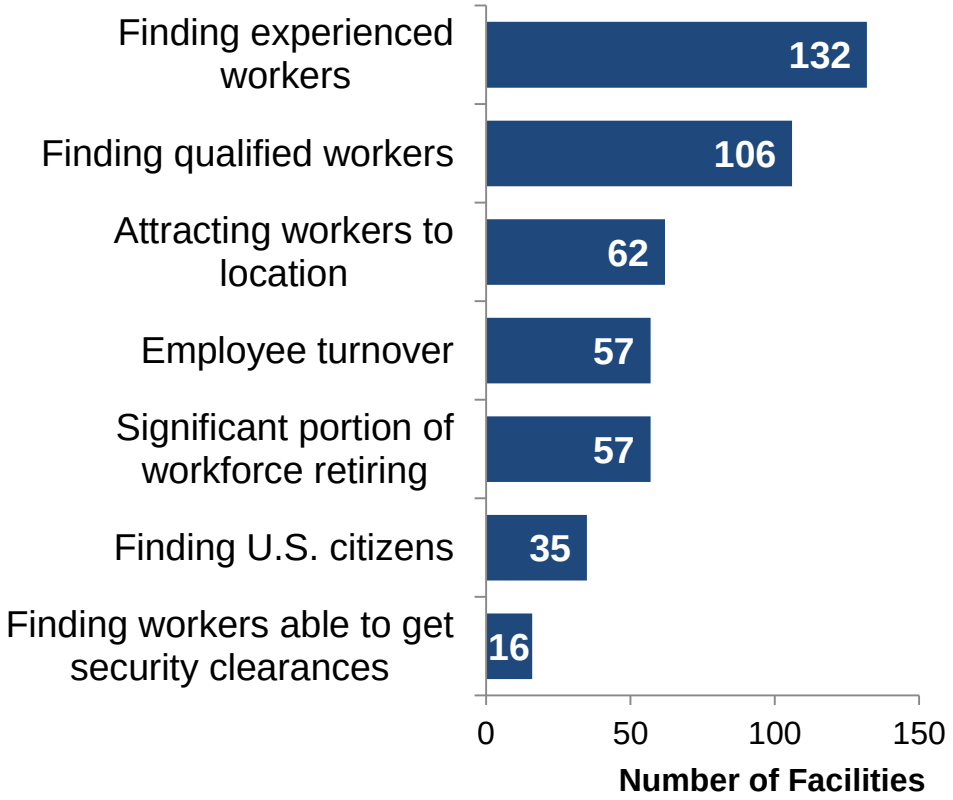
Industry Hiring and Retention Issues (2015)

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



202 respondents

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



202 respondents

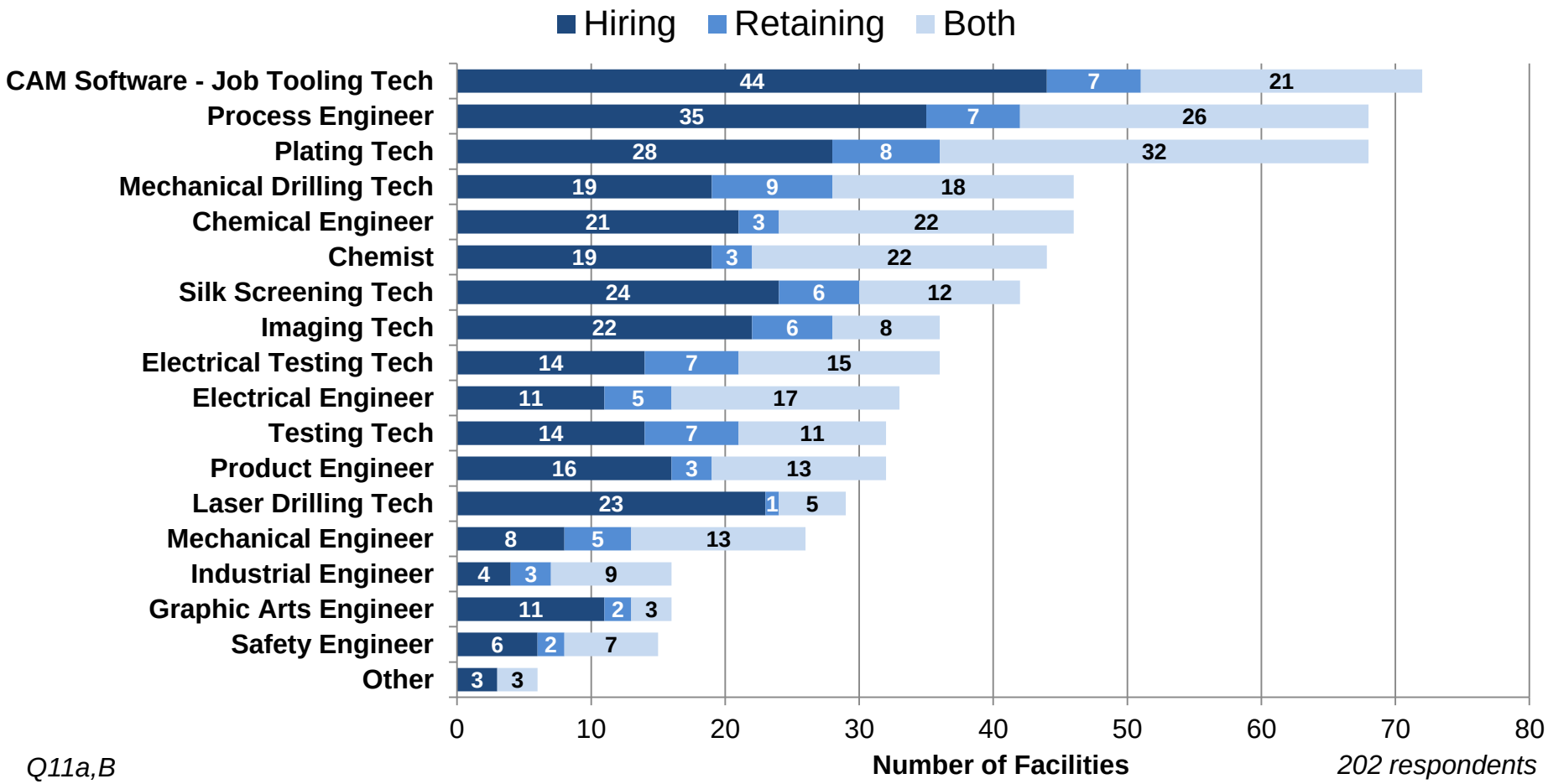
Q11a, B/C

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?



Q11a,B

202 respondents

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

Employment – Challenges (2015)

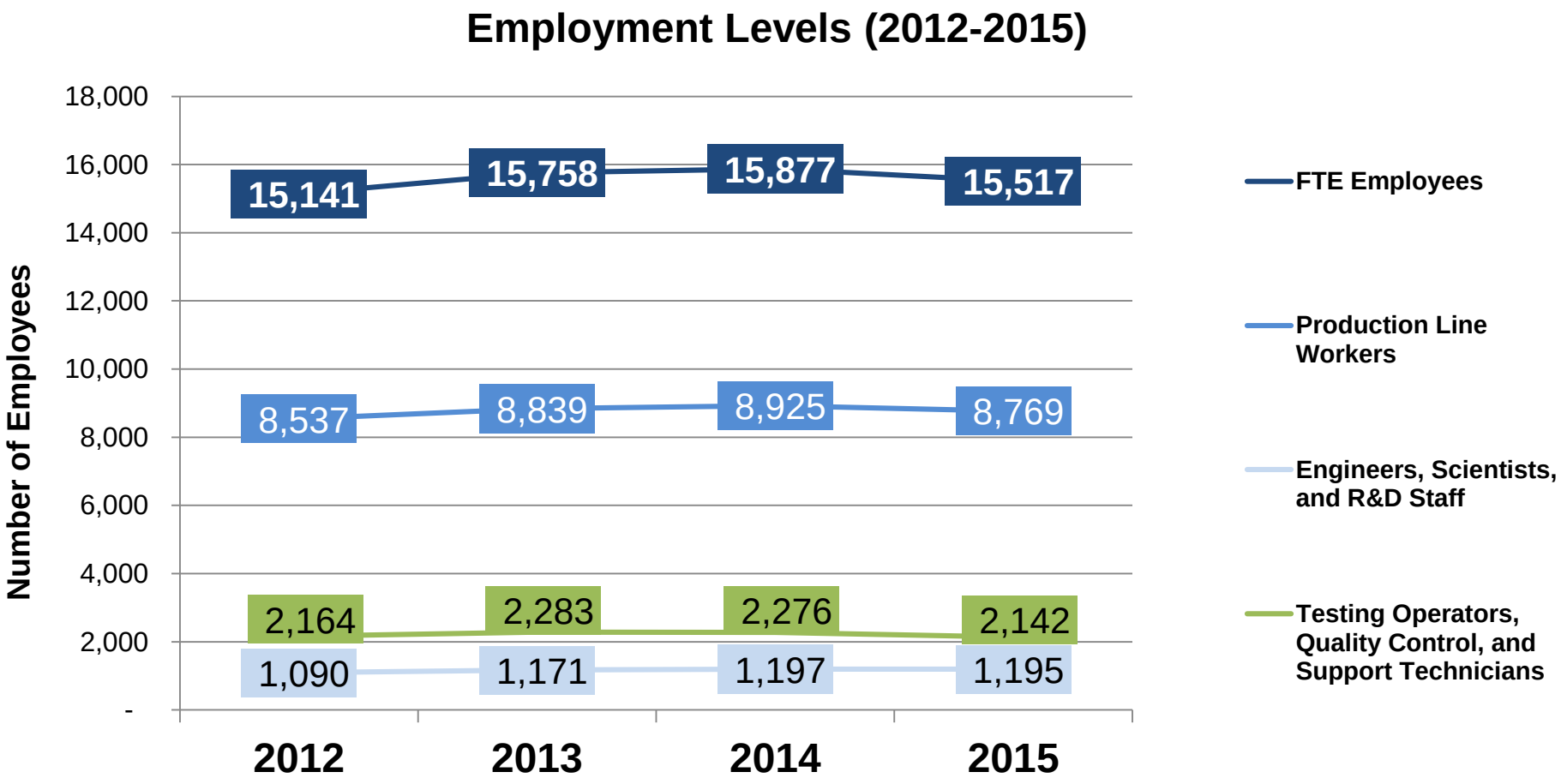
- The industry's ability to recruit and hire a qualified sustainable workforce seems to be limited by two key factors.
  - Shortage of prospective employees who have the essential skills needed to be successful in a PCB manufacturing capacity.
  - A shortage of young people interested in manufacturing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

U.S. Bare PCB Facility Workforce



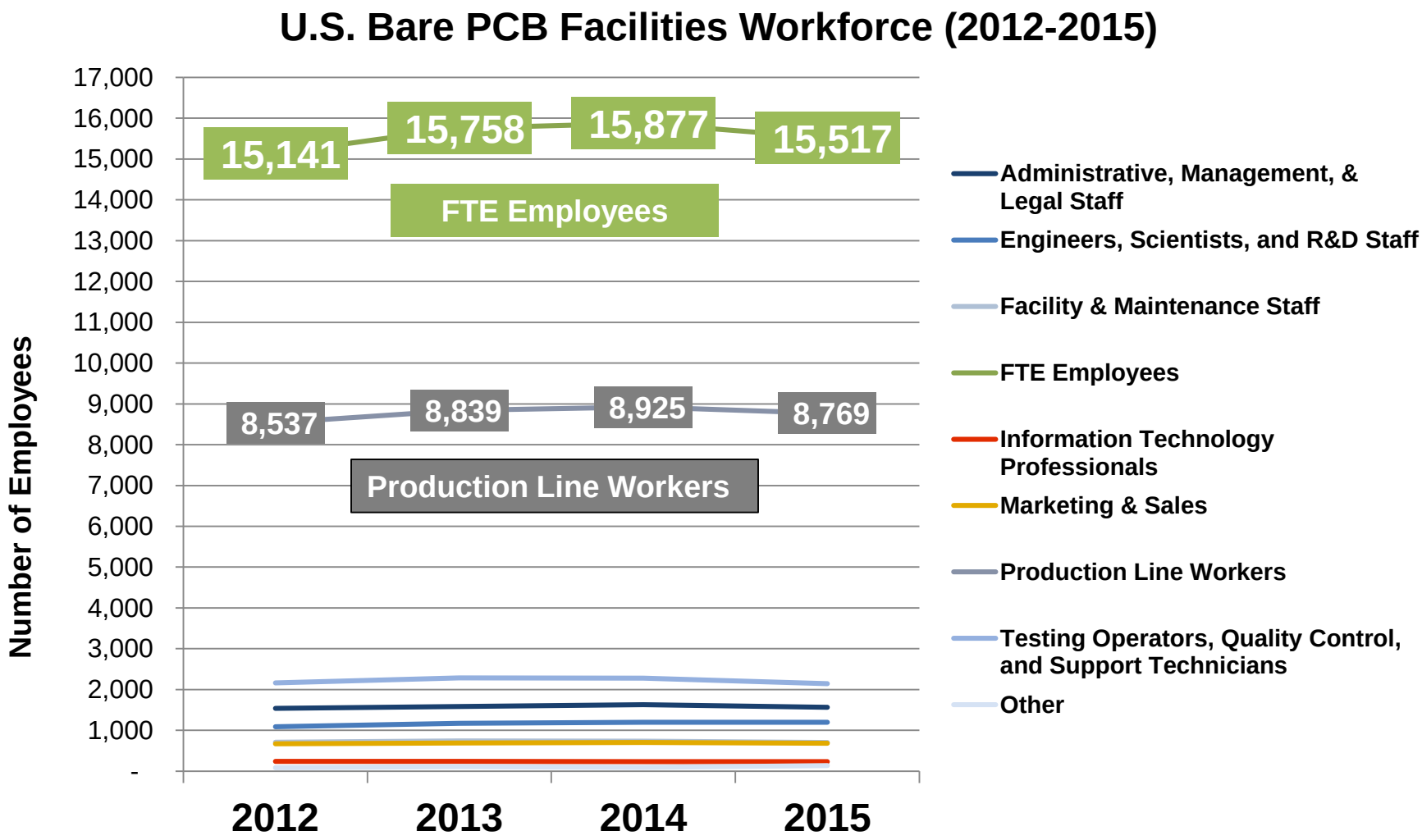
13% of technical staff (scientists, engineers, R&D staff) are expected to retire by 2020.

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 Workforce - Total v. Production Line

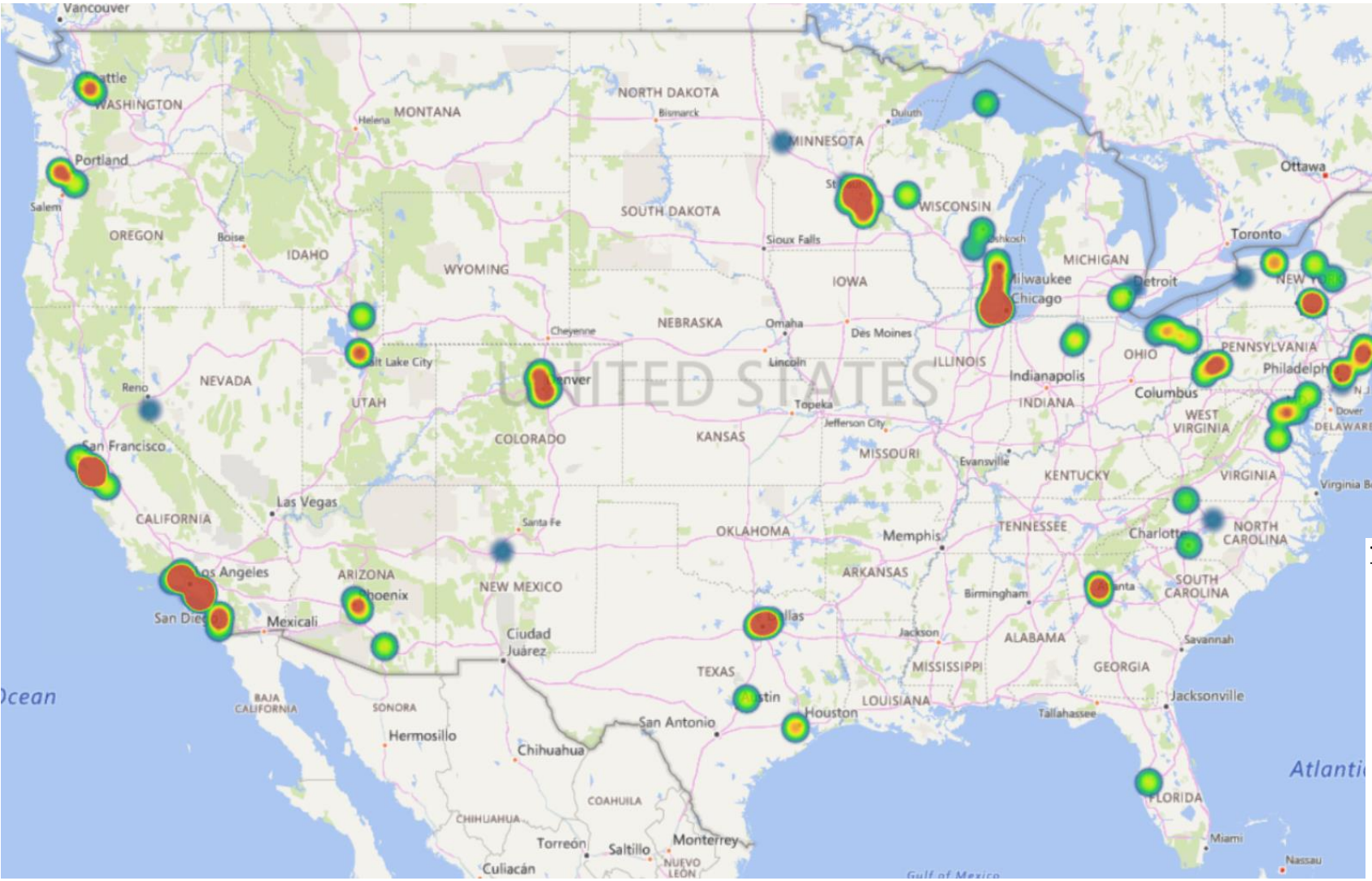


Q11a,A

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 Facility Workforce – Geographic Location (2015)



Top 10 States	Number of Employees
CA	5,349
WI	1,403
MN	1,215
IL	1,160
NY	920
OR	839
CO	665
VA	468
UT	438
NH	417

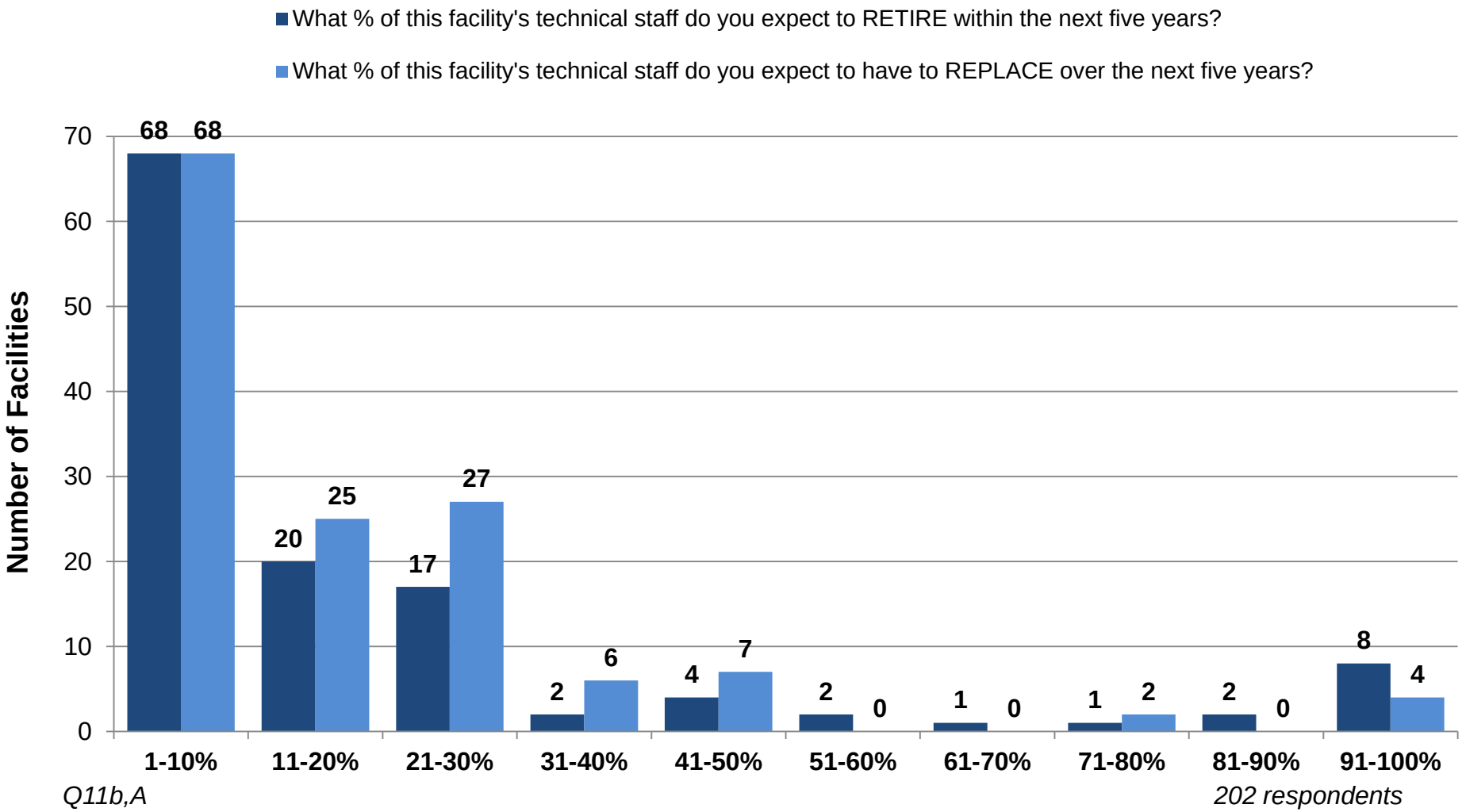
Q11a,A

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 Workforce – Technical Staff Turnover

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



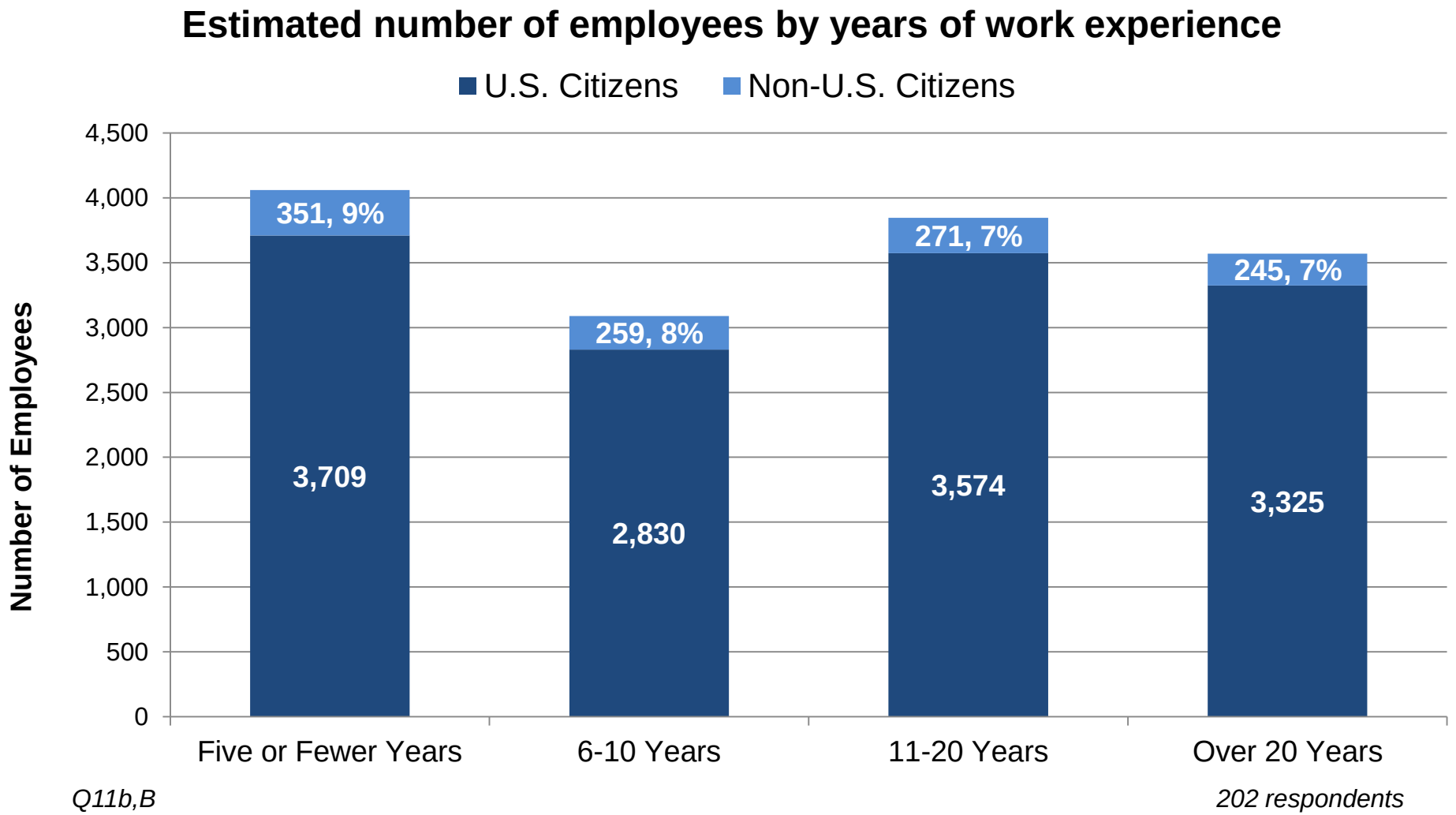
Q11b,A

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

Level of Work Experience for U.S./Non-U.S. Workers (2015)



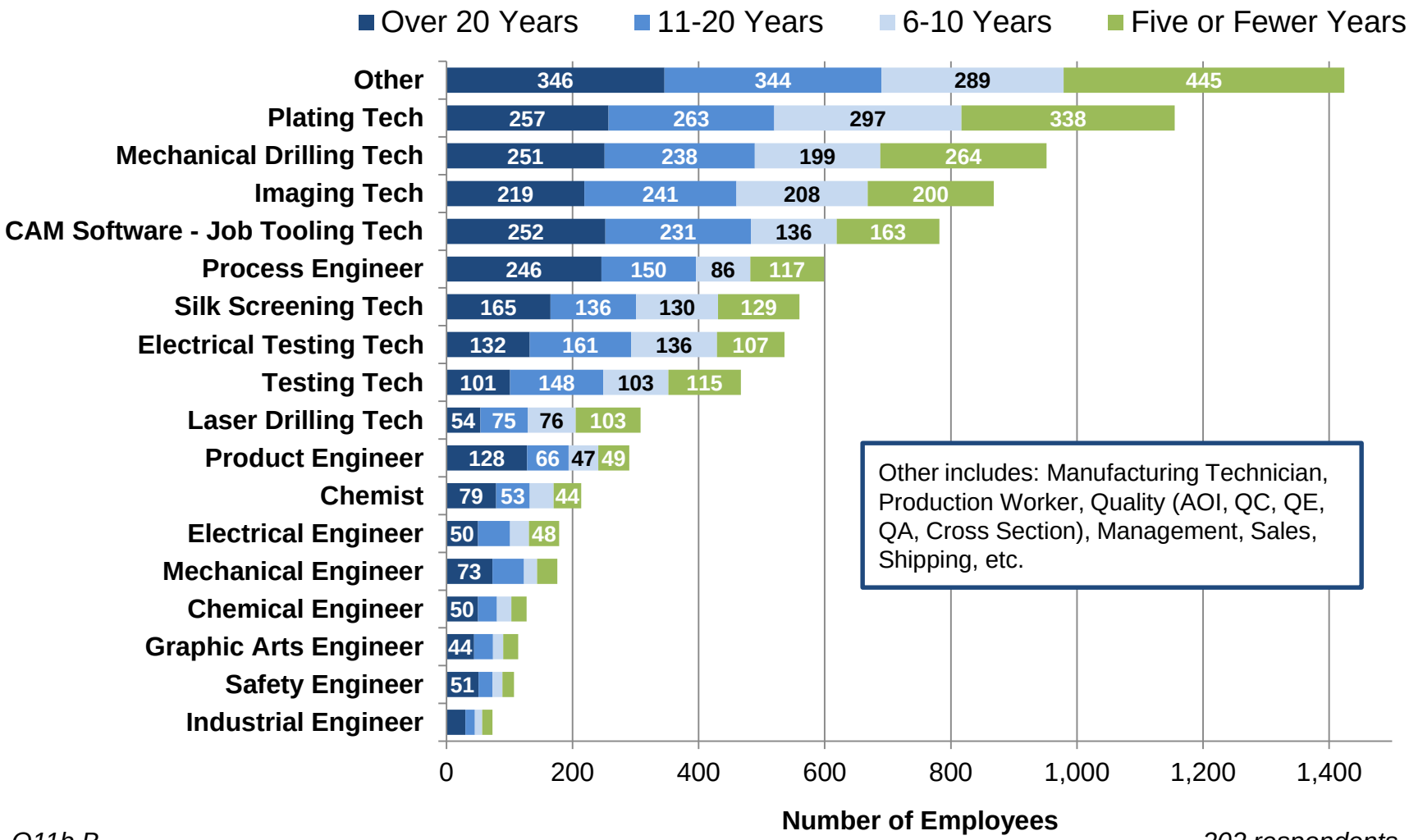
Q11b,B

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

Level of Work Experience by Job Category (2015)



Q11b,B

202 respondents

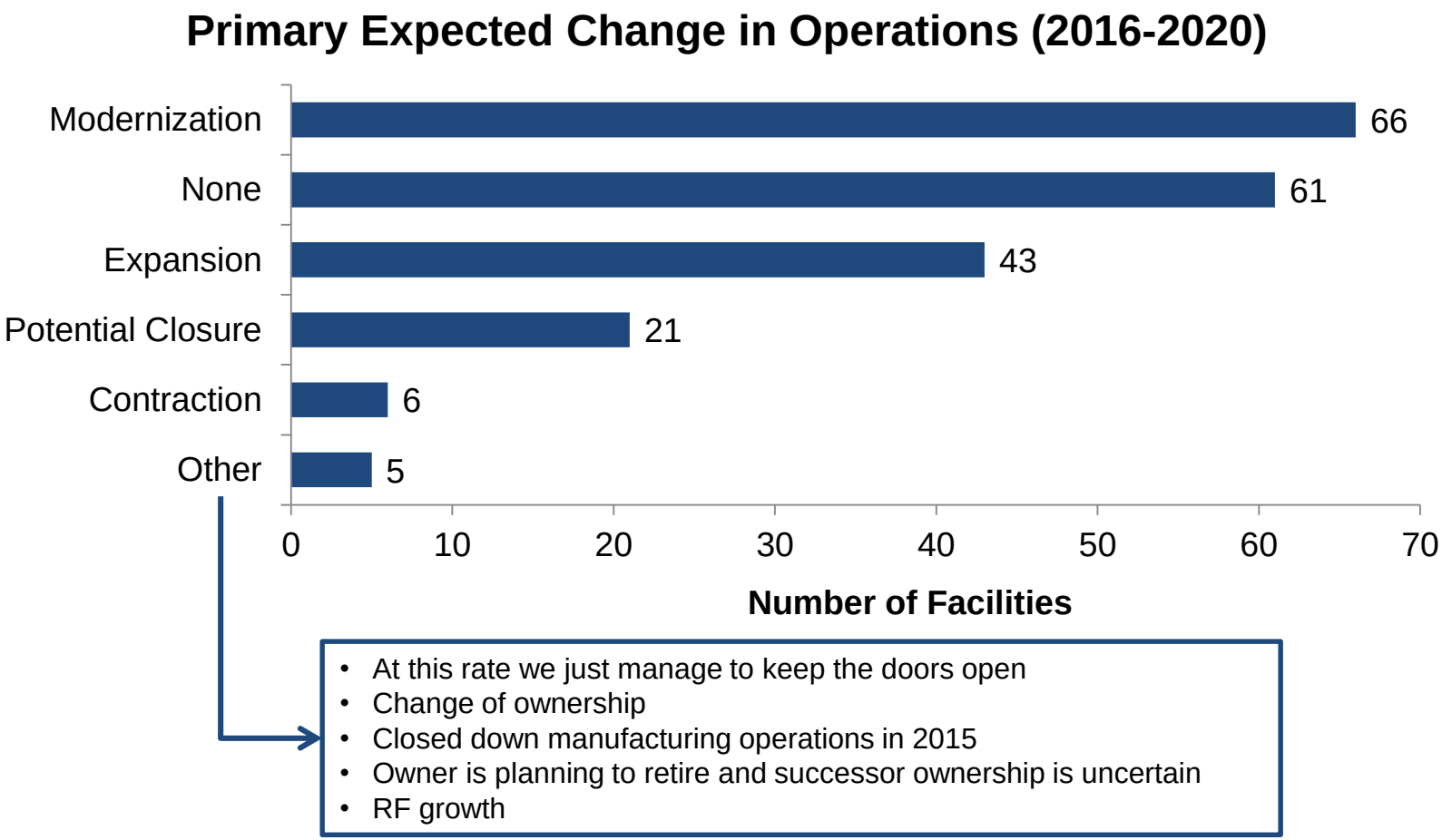
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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

Competitive Factors

Primary Projected Changes for U.S. Bare PCB Facilities



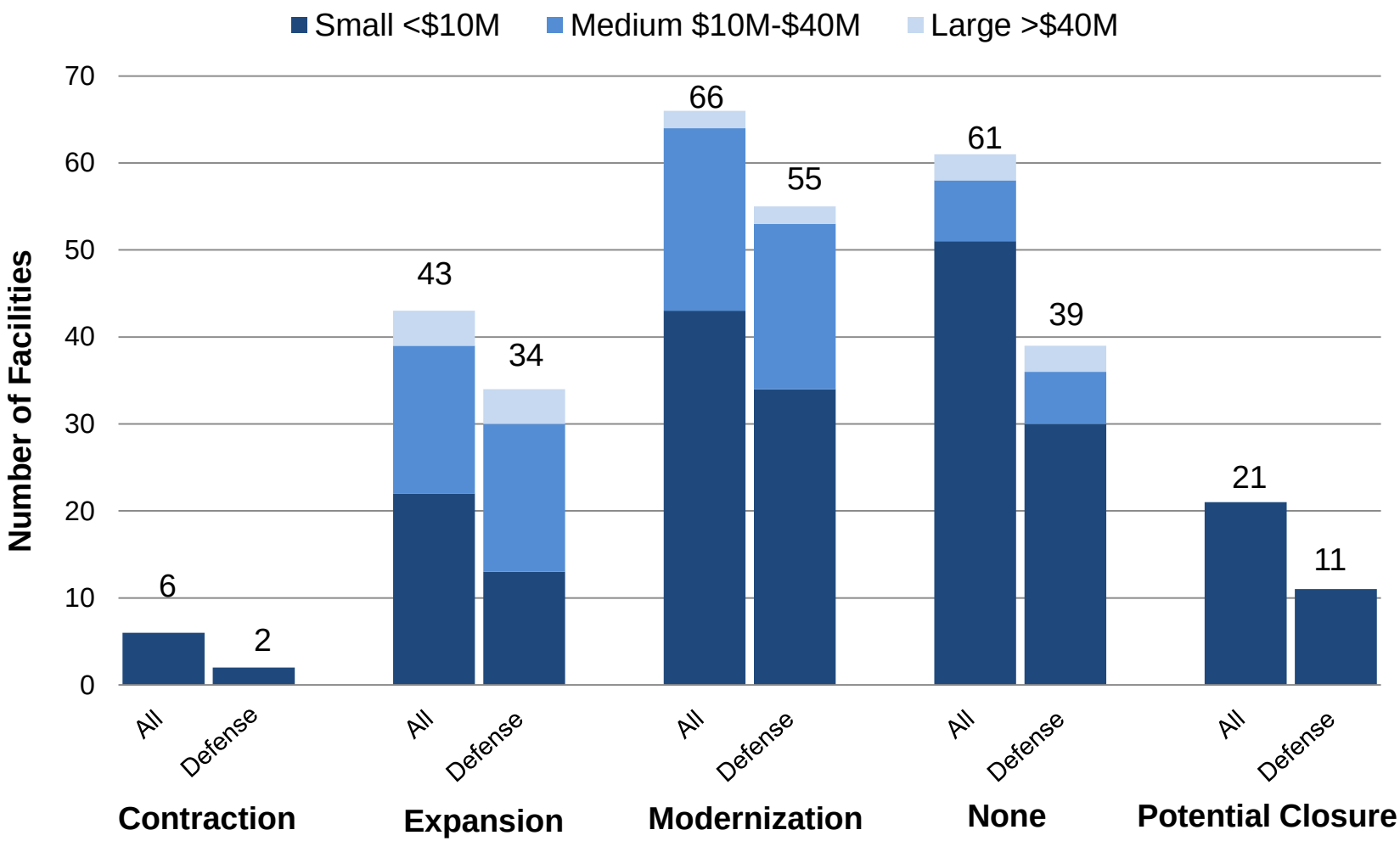
Q12a, A

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

202 respondents

Competitive Factors

Changes Expected at U.S. Bare PCB Facilities (2016-2020)



Q12a, A

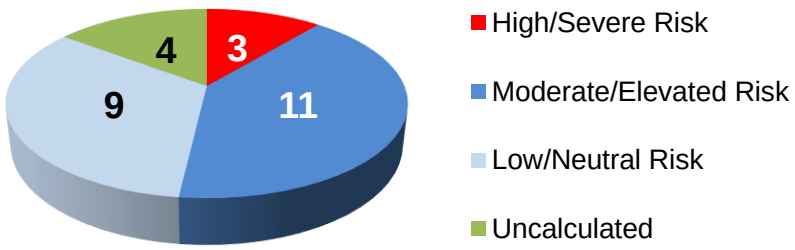
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

197 Respondents

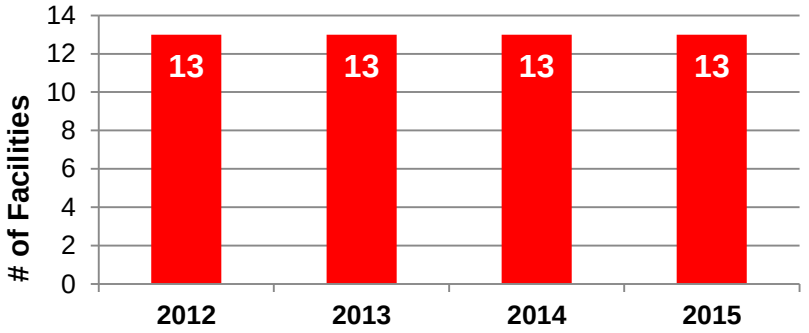
Competitive Factors - Facilities Eyeing Contraction (2016-2020)

- **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

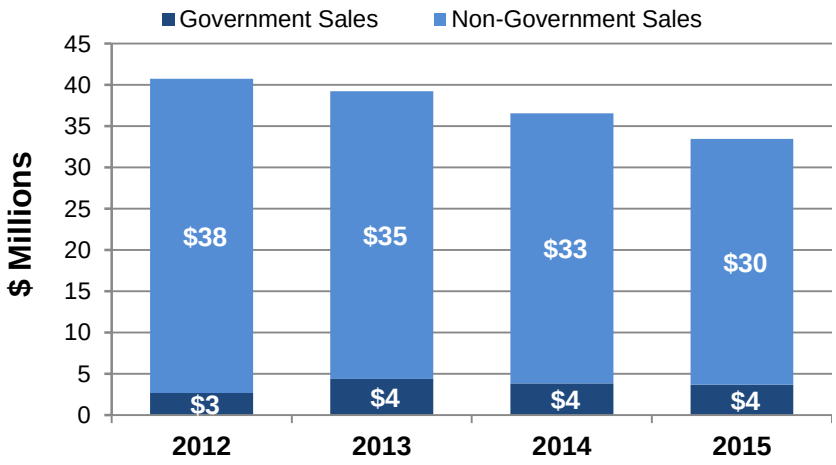
Financial Risk Rating



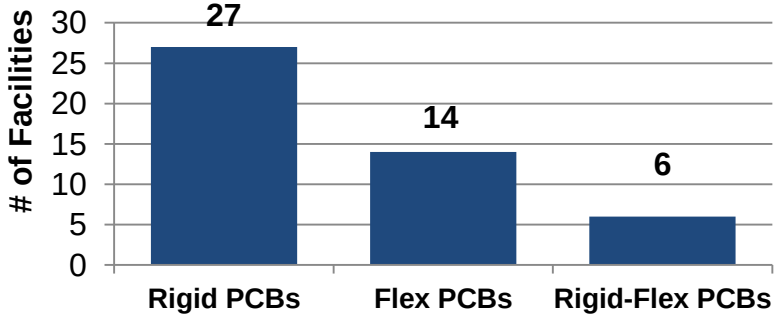
Net Income < $0



U.S. Bare PCB Sales



Manufacturing Capabilities – Board Types



Q12a, A

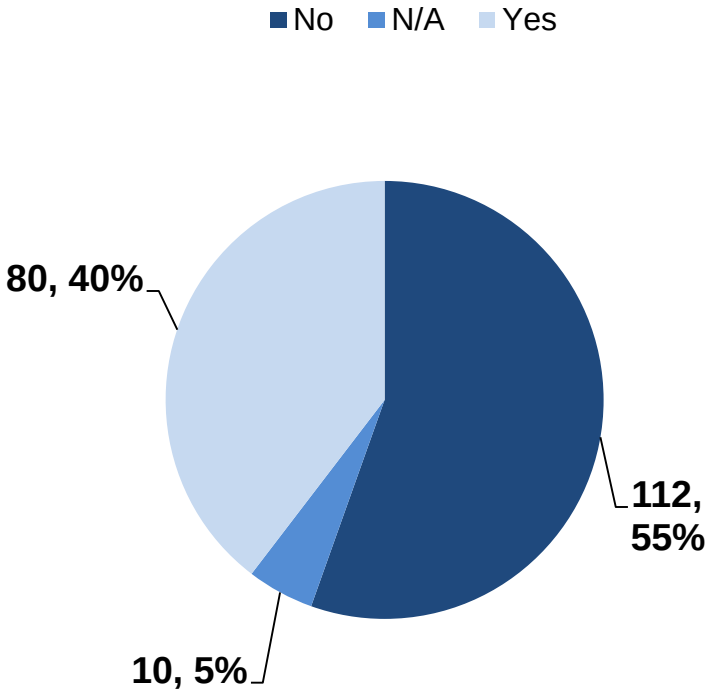
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

27 Respondents

Competitive Factors

Effect of Environmental Regulations on U.S. PCB Facilities (2015)

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



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

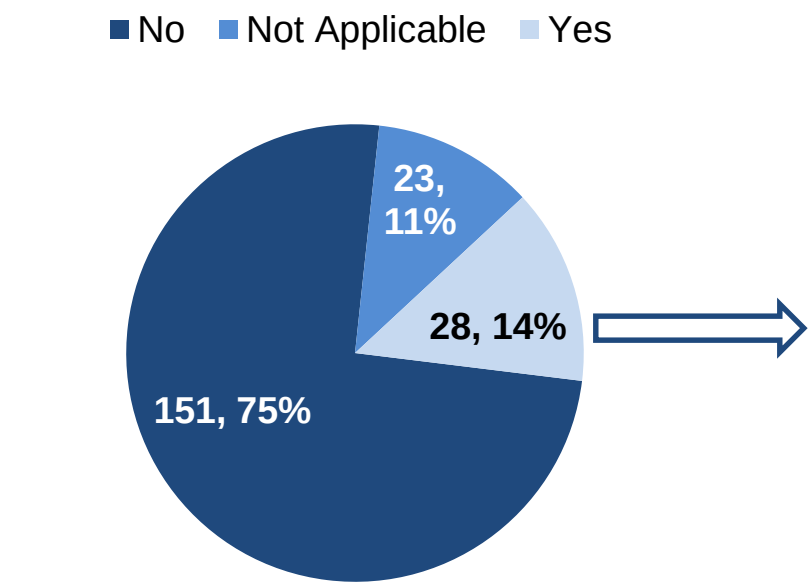
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

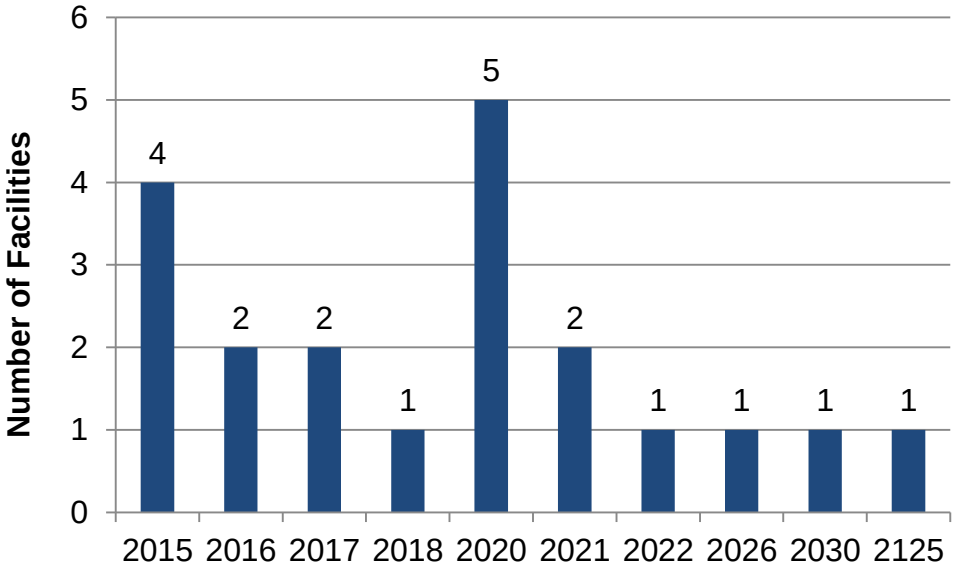
Competitive Factors

Forecast Closures of U.S. Bare PCB Tin-Lead Facilities (2015)

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



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



*Note: Eight "Yes" respondents either did not provide a year or provided a year prior to the period covered in the survey.

Q12a,B2

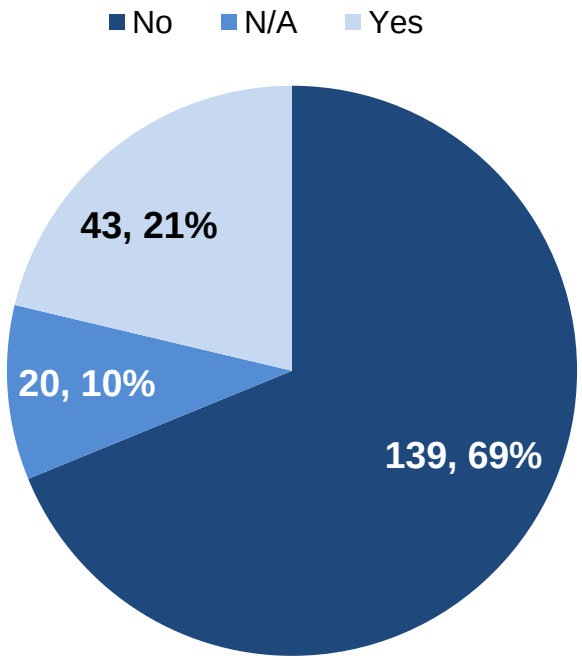
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

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?



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 chemistries, 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."

Q12a,B3

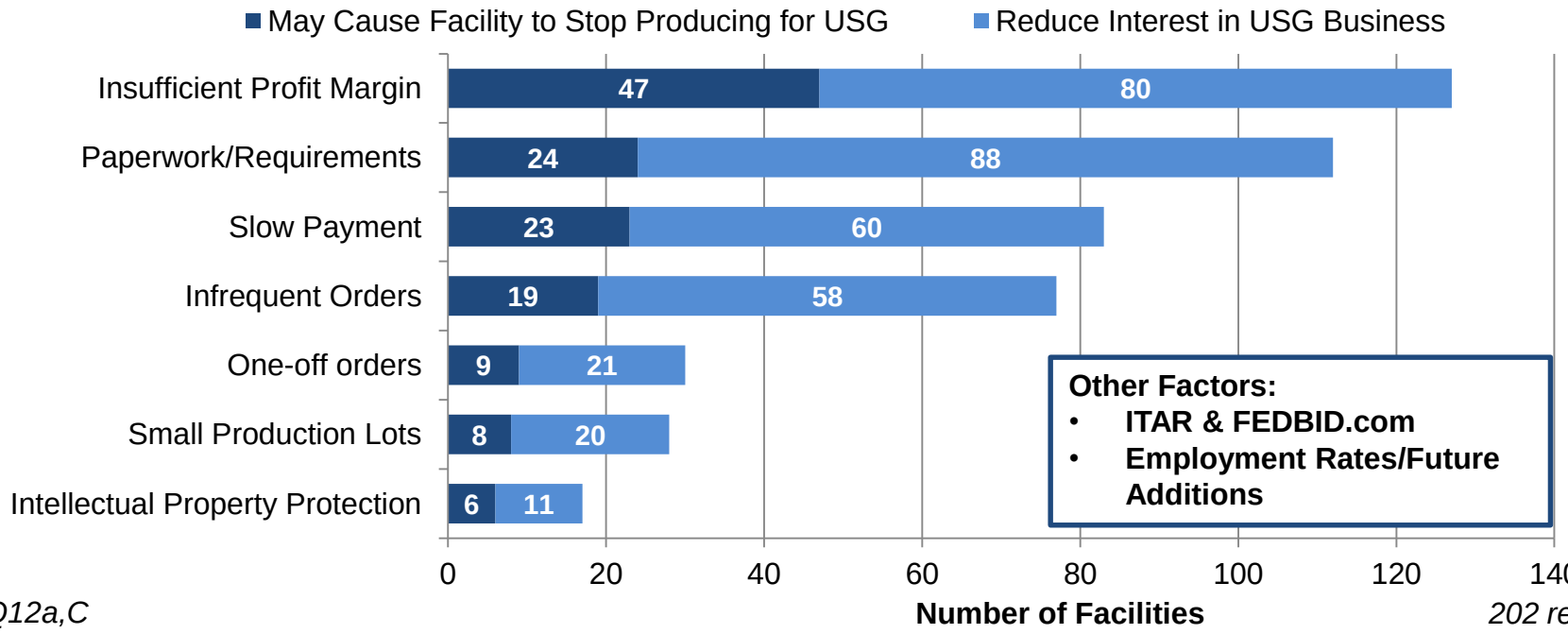
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Factors Affecting Facility Interest in USG Business (2015)

- 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.



Q12a,C

202 respondents

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

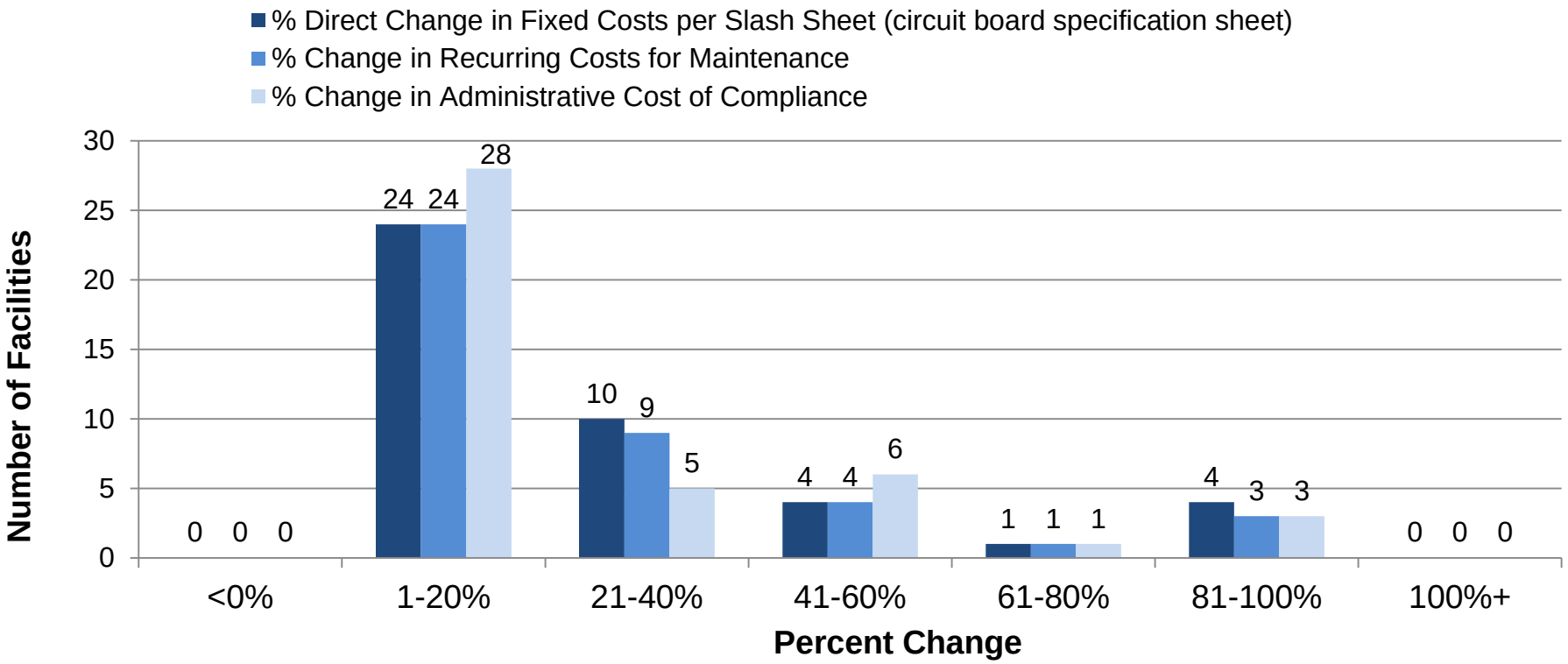
Competitive Factors

Cost Effect of DOD Standard MIL-PRF-31032 (2015)

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.



Q12a, D

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

43 respondents

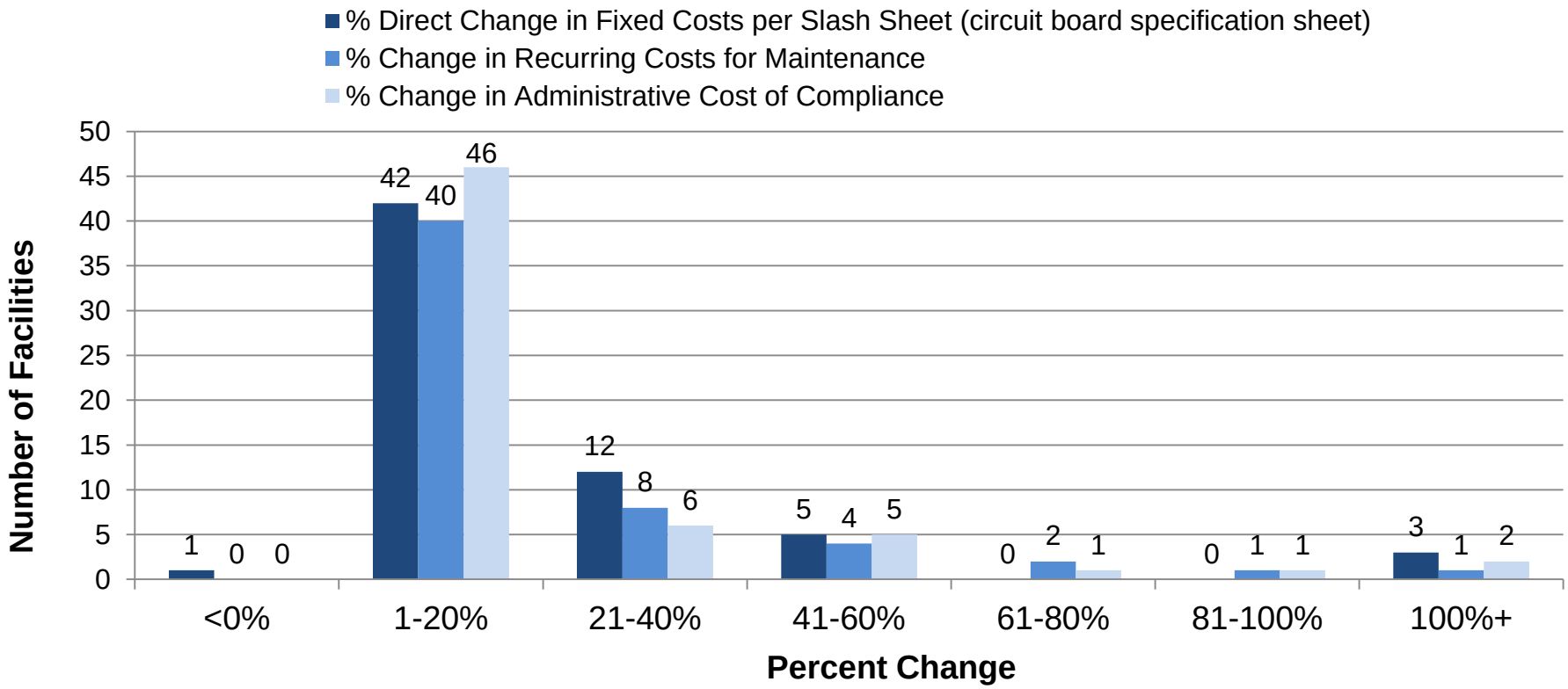
Competitive Factors

Cost Effect of DOD Standard MIL-PRF-31032 (2015)

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



Q12a, D

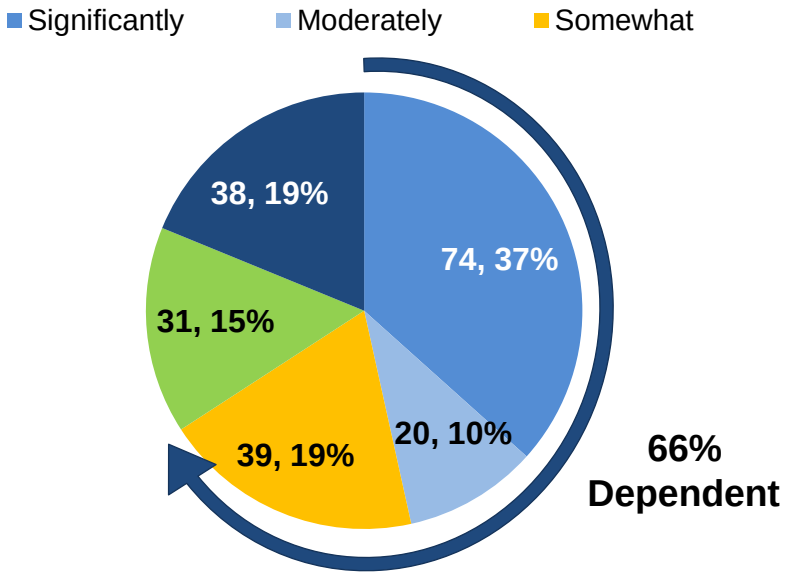
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

61 respondents

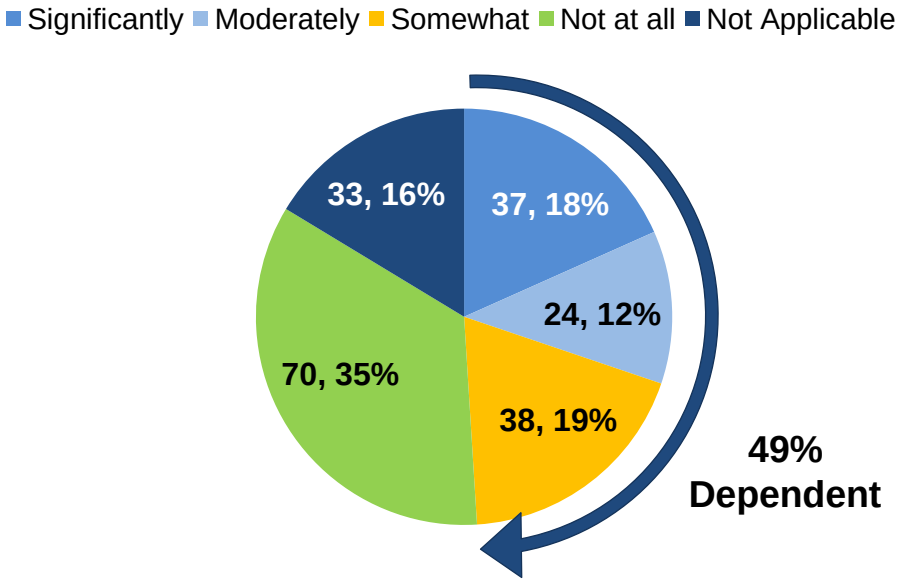
Competitive Factors – Reliance on USG Business (2015)

- 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?



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?



Q12b,A

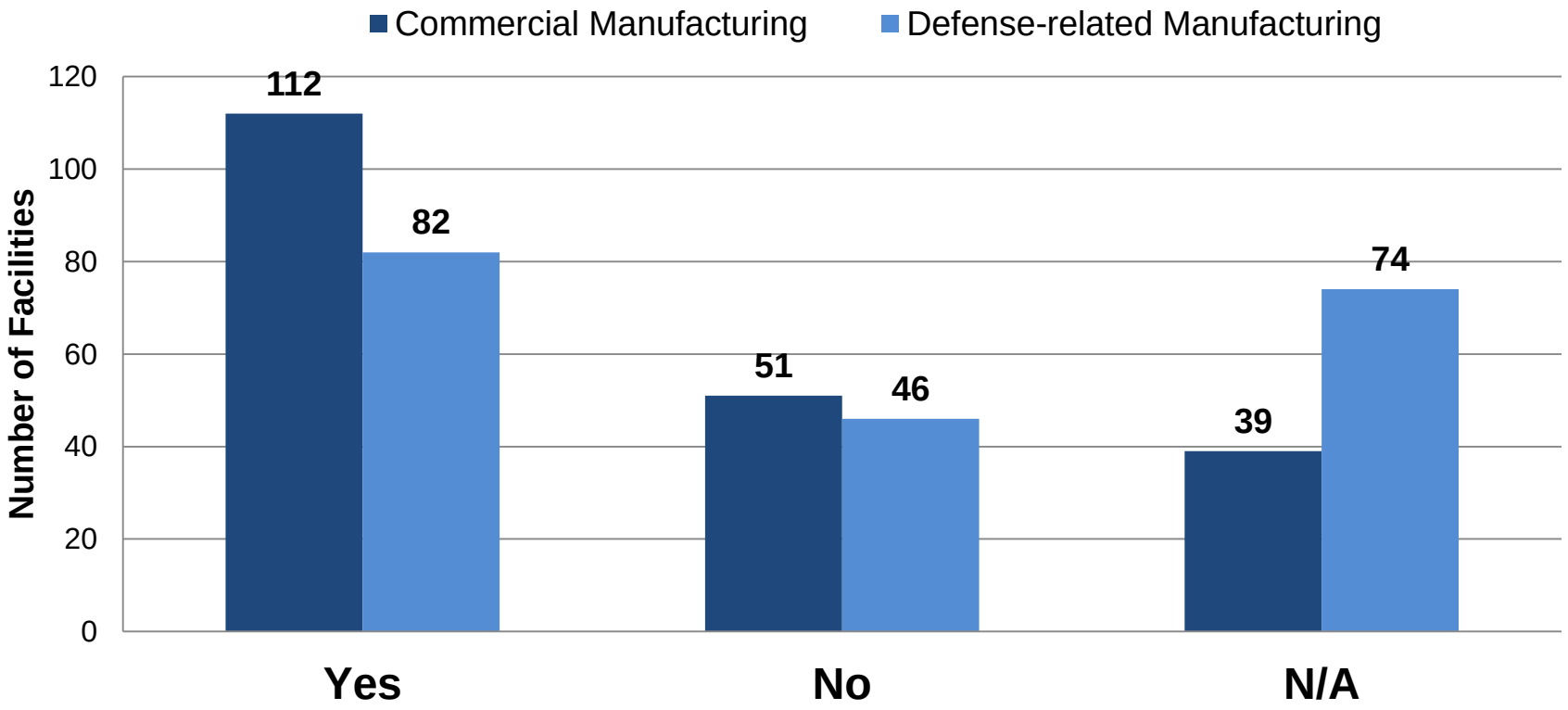
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

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?



Q12b, A

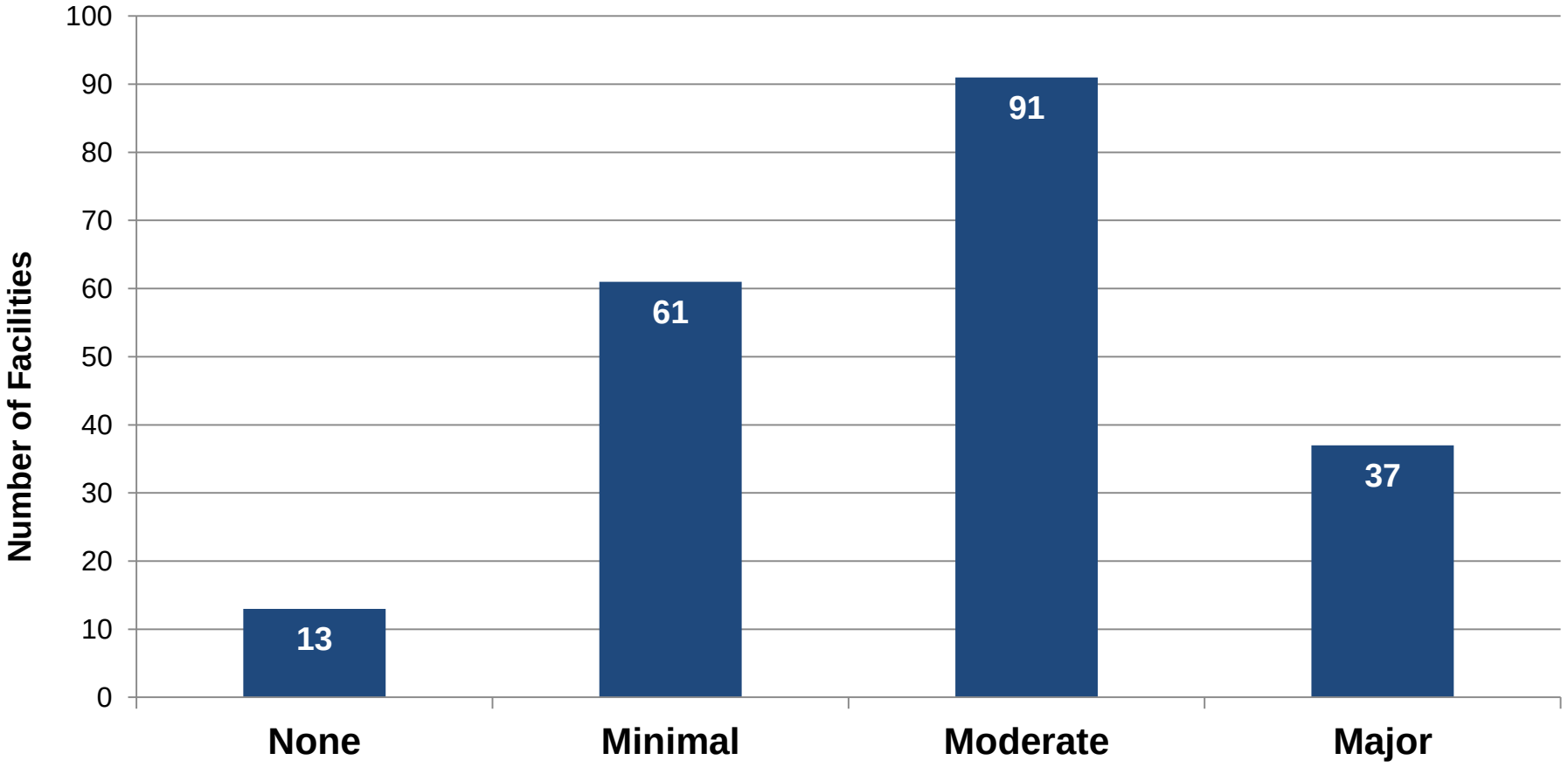
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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?



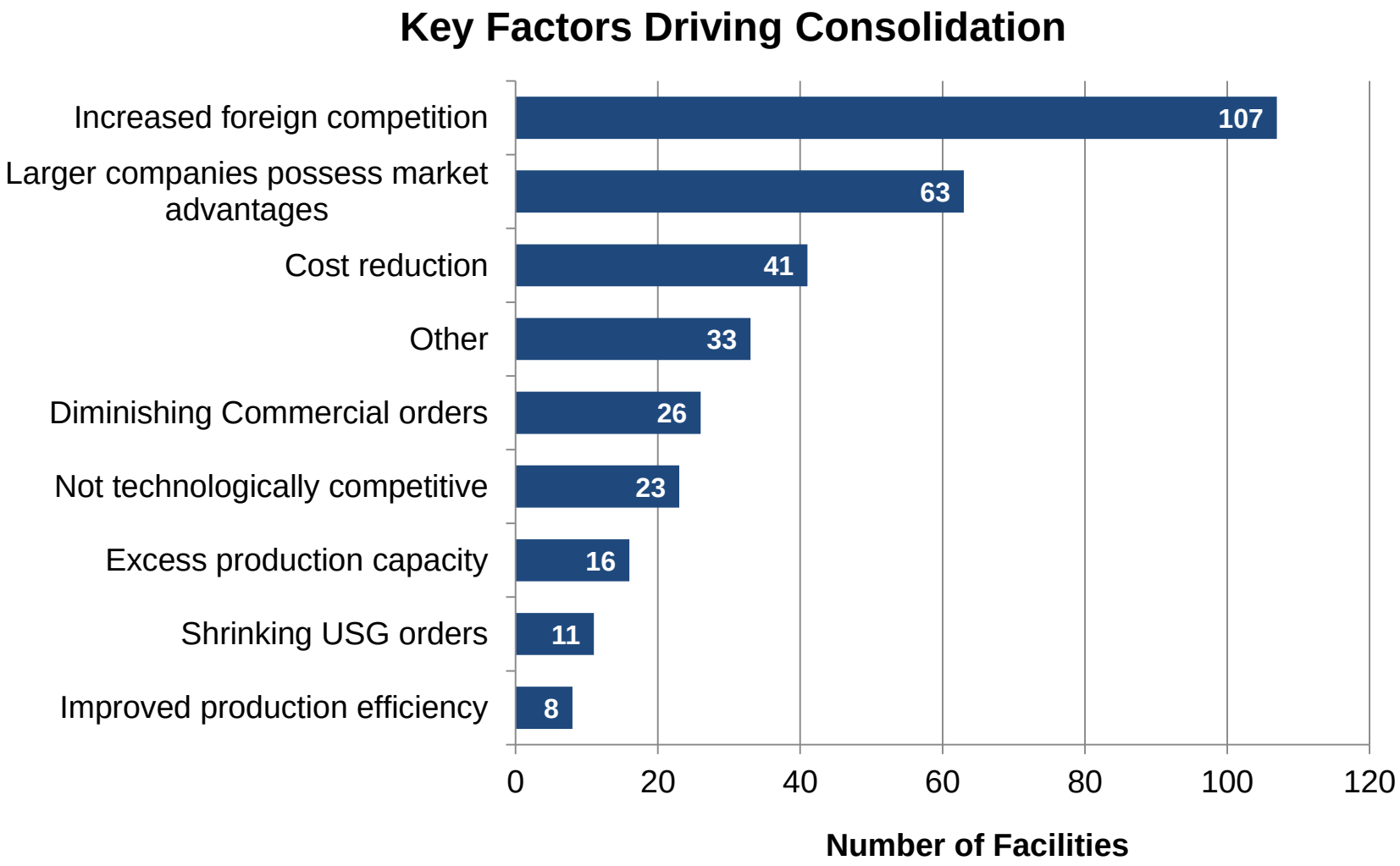
Q12b, B

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

202 respondents

Competitive Factors

U.S. PCB Facility Views of Issues Driving Consolidation (2015)



Q12b, B

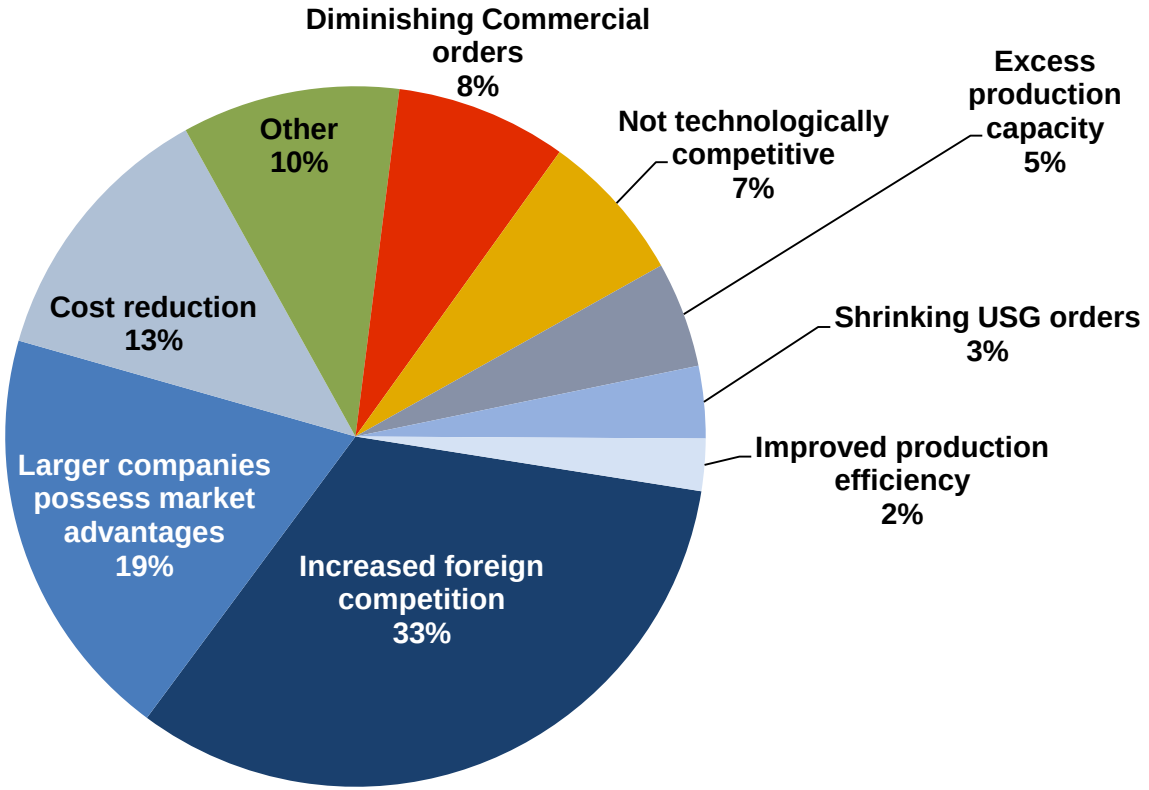
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Competitive Factors

Consolidation Drivers Identified by U.S. PCB Companies (2015)

Percent of Companies Identifying Key Factor as Cause for Consolidation



Q12b,B

202 respondents

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."

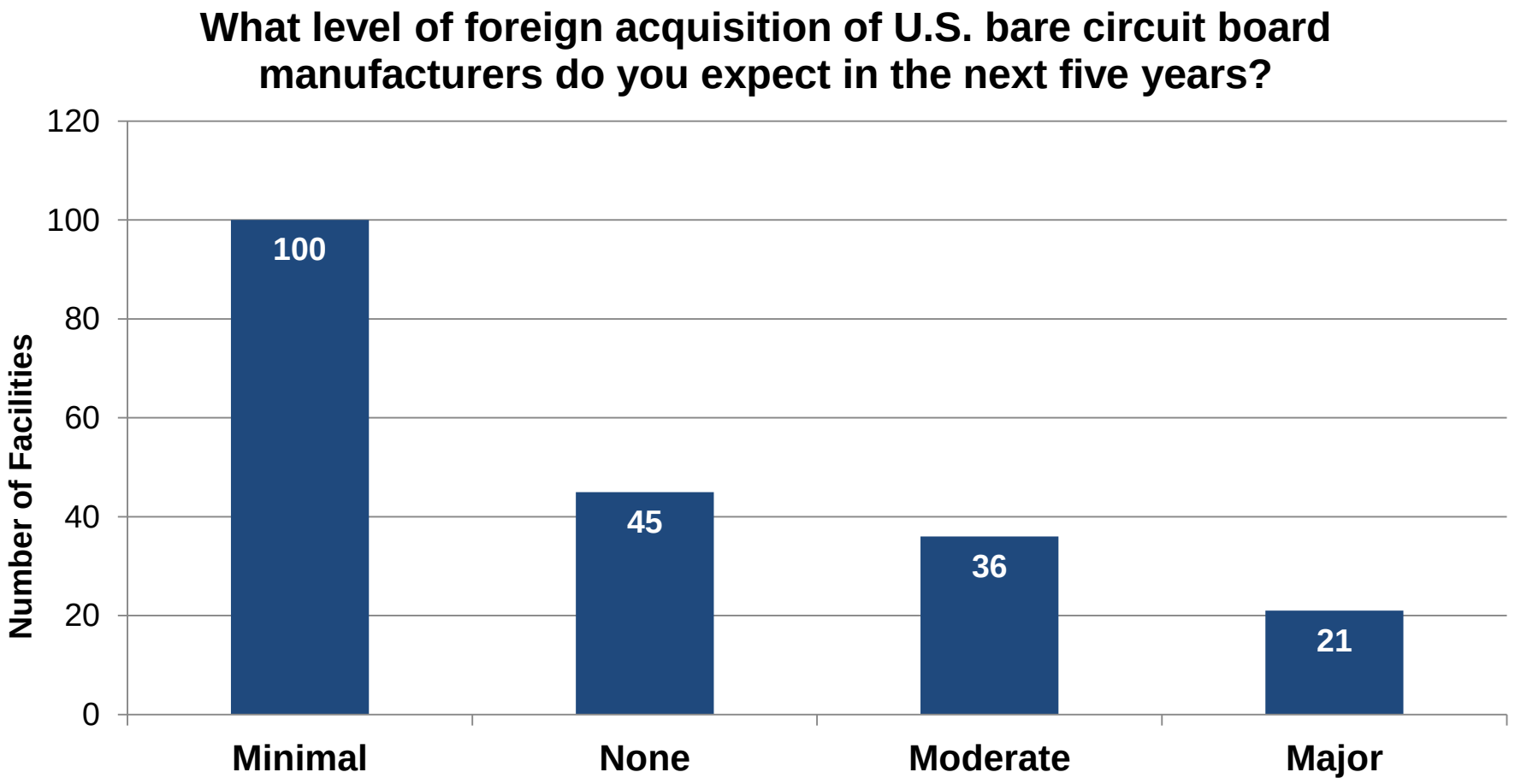
Q12b,B

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

202 respondents

Competitive Factors

Outlook for Foreign Acquisitions of U.S. Bare PCB Facilities (2016-2020)



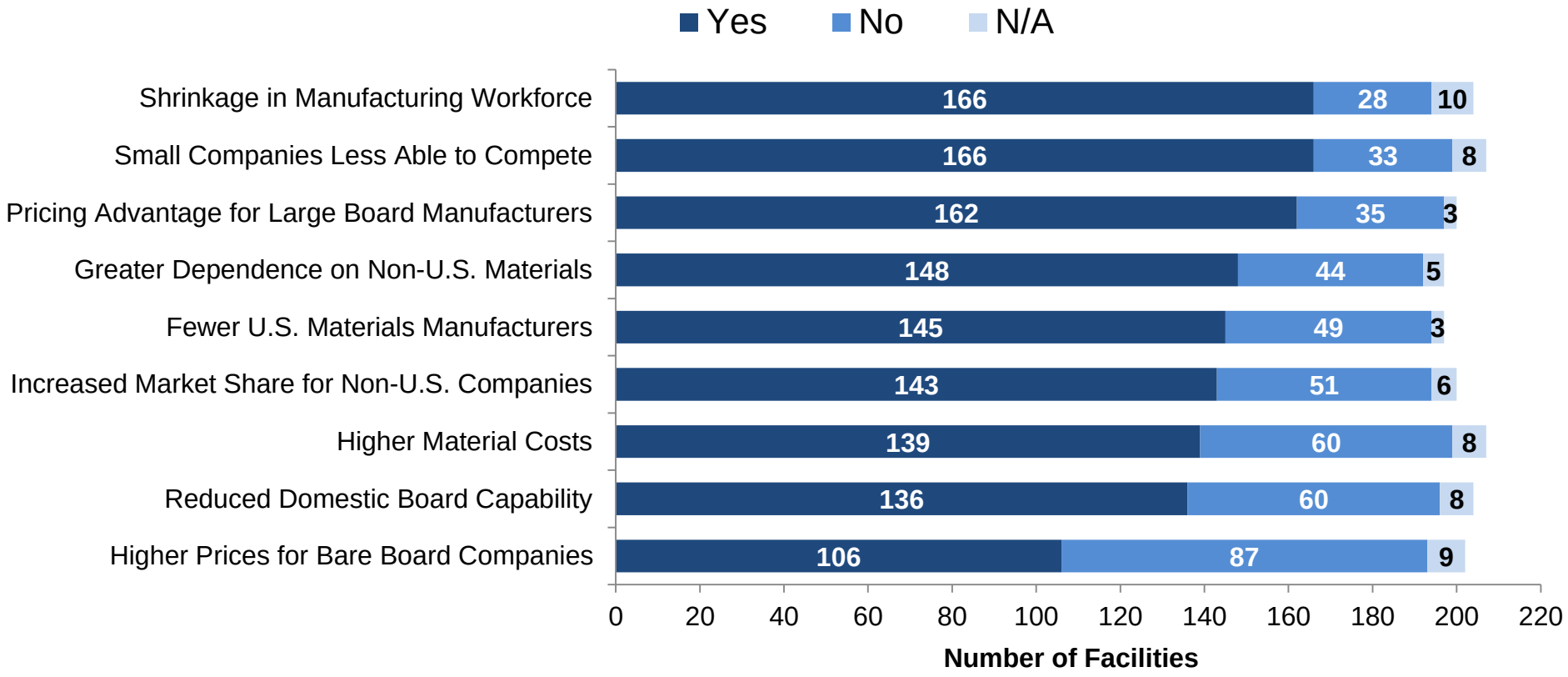
Q12b, B

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

202 respondents

Competitive Factors – Views on Consolidation Effects (2015)

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



*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.

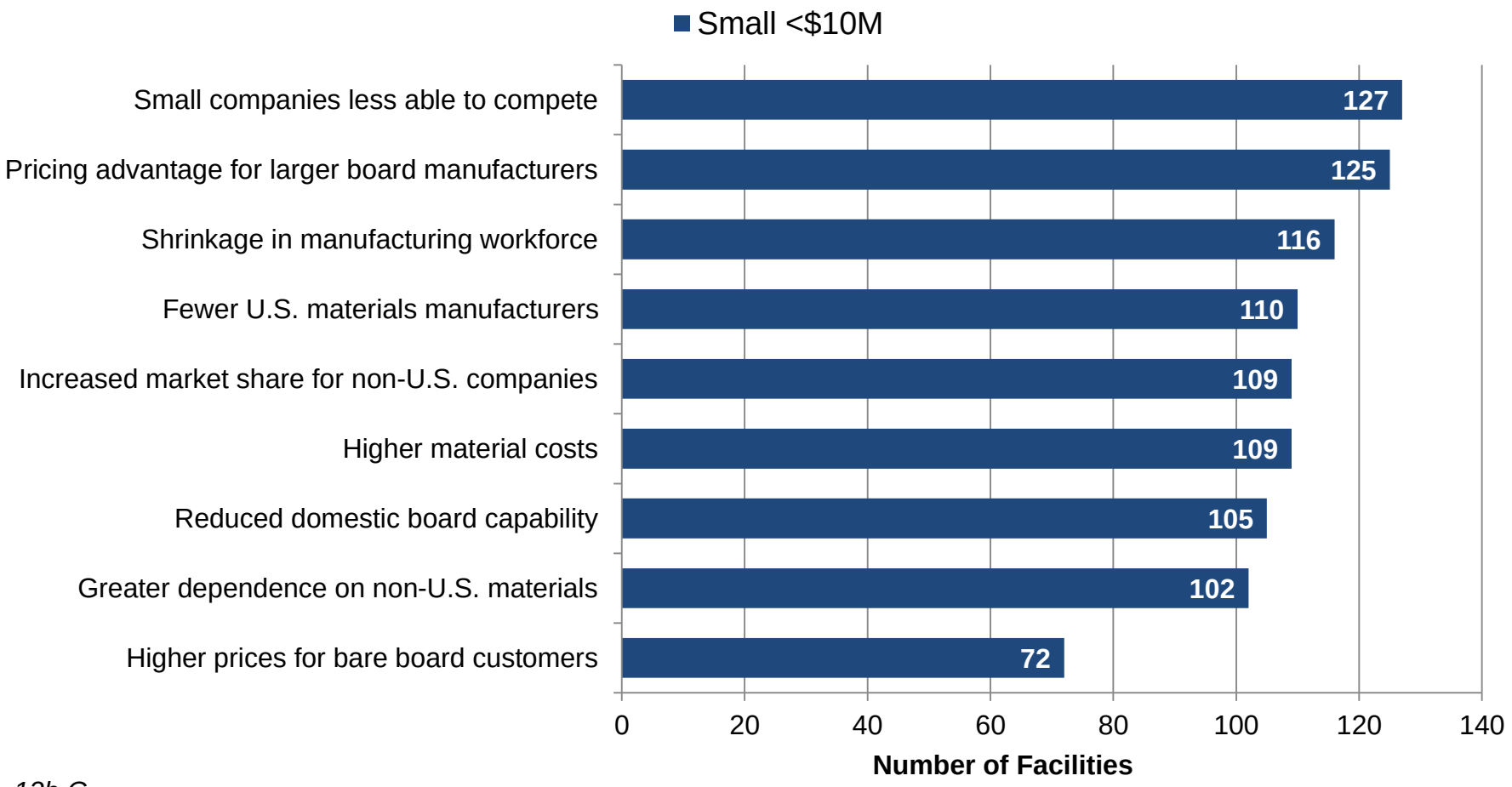
Q12b,C

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

202 respondents

Competitive Factors – Views on Consolidation Effects (2015)
Small Facilities

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



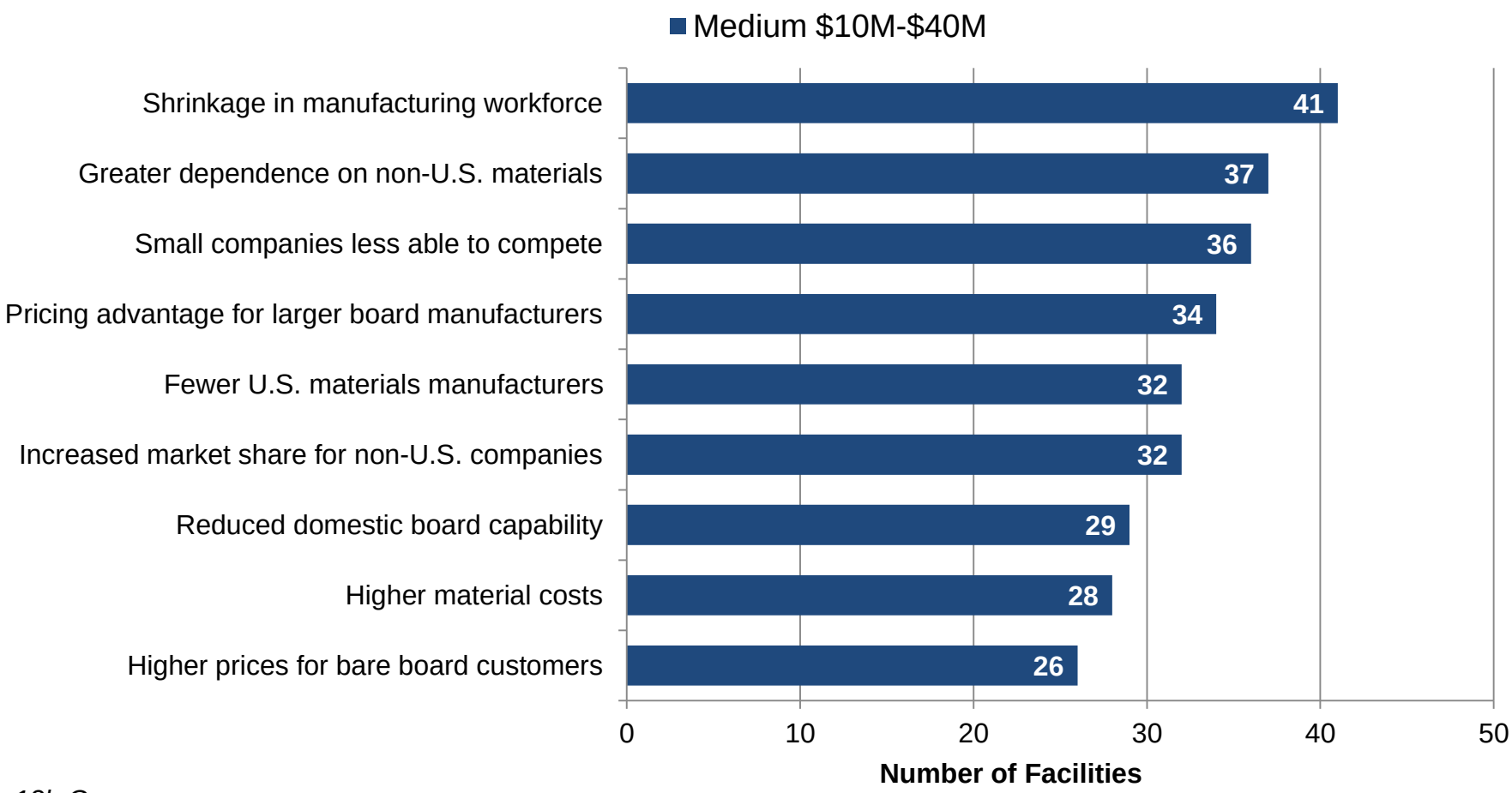
12b,C

146 respondents

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

Competitive Factors – Views on Consolidation Effects (2015)
Medium Facilities

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



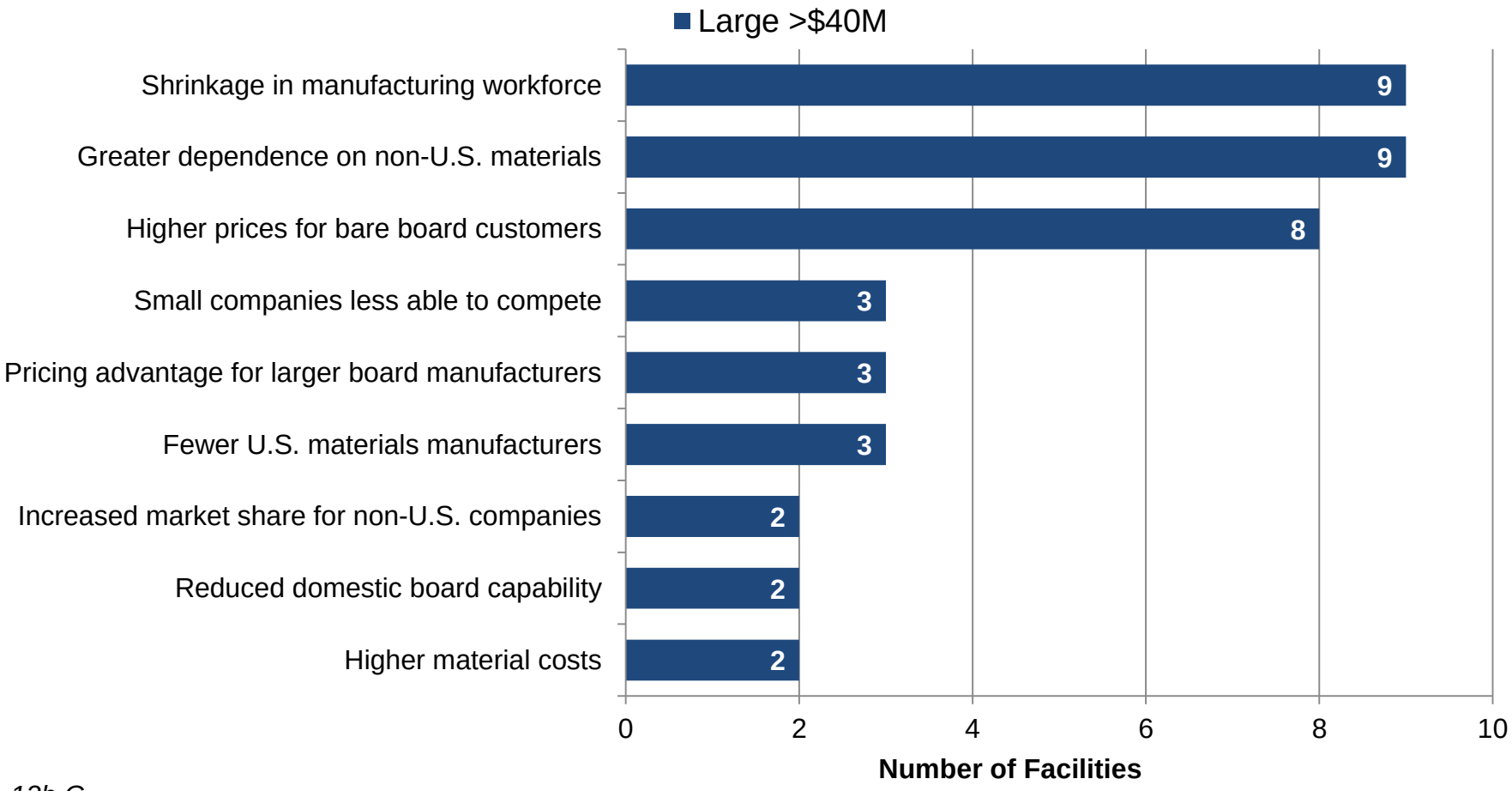
12b,C

46 respondents

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

Competitive Factors – Views on Consolidation Effects (2015)
Large Facilities

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



12b,C

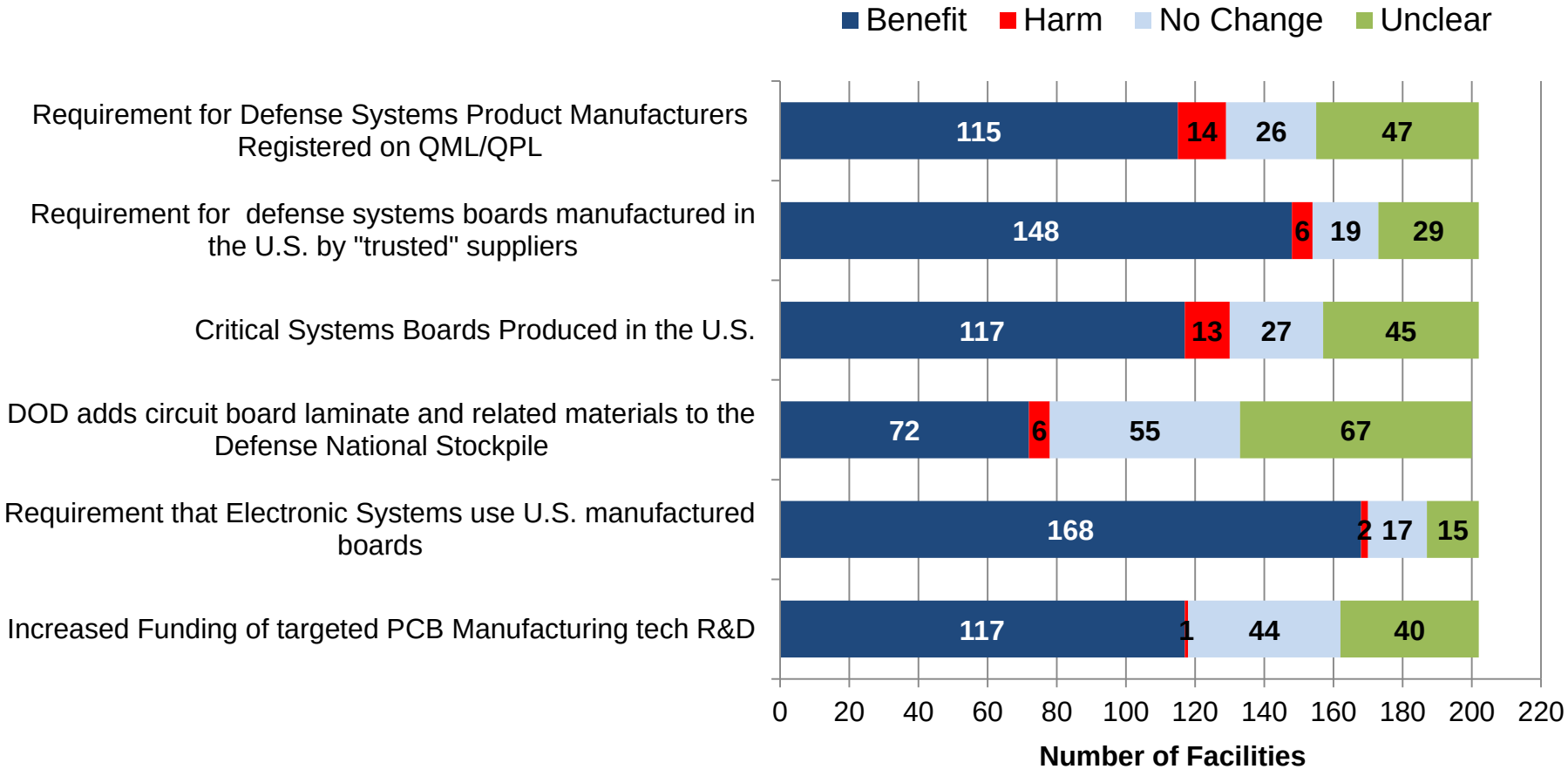
10 respondents

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

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?



Q12c,A

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

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."

Q12c,A

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

202 respondents

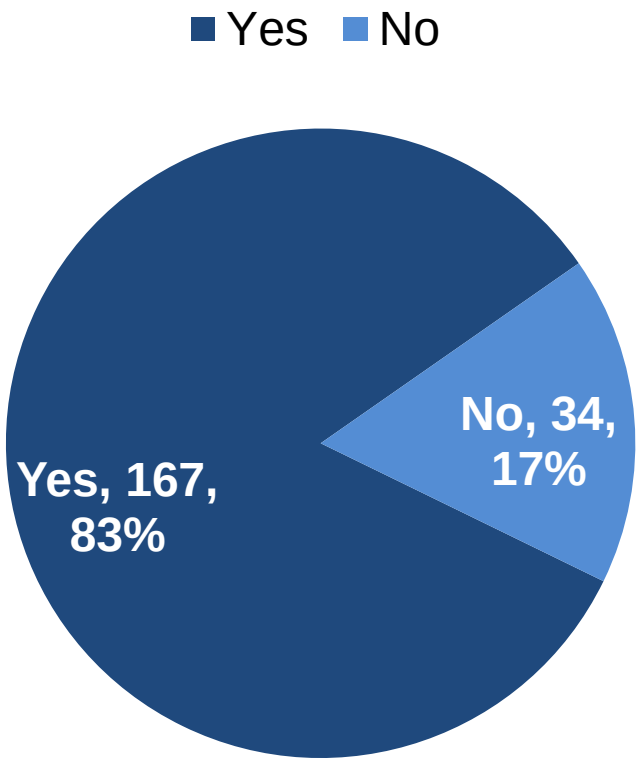
CHAPTER 11:
CYBER SECURITY

- 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?



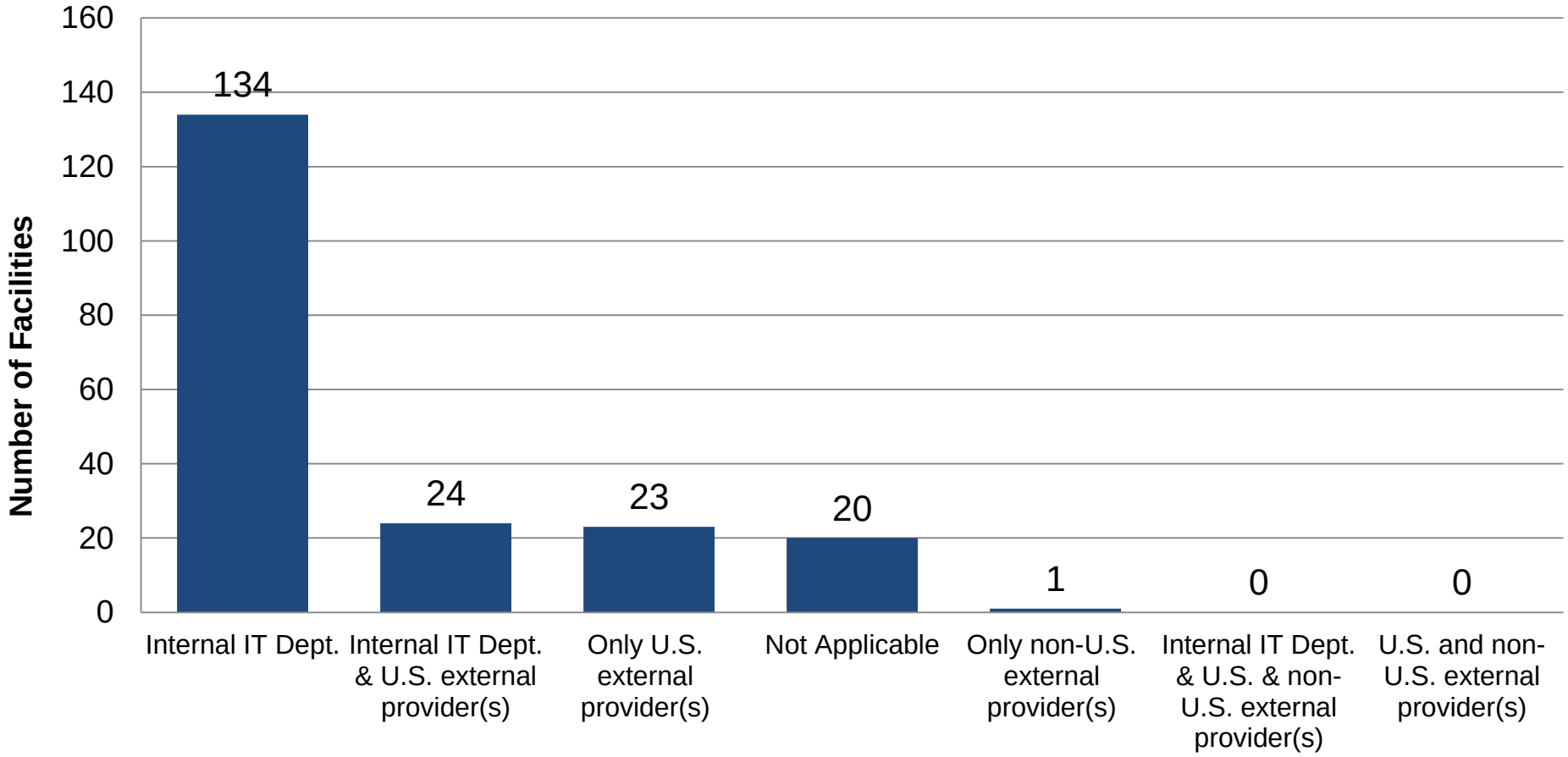
Q13a,A

201 respondents

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:



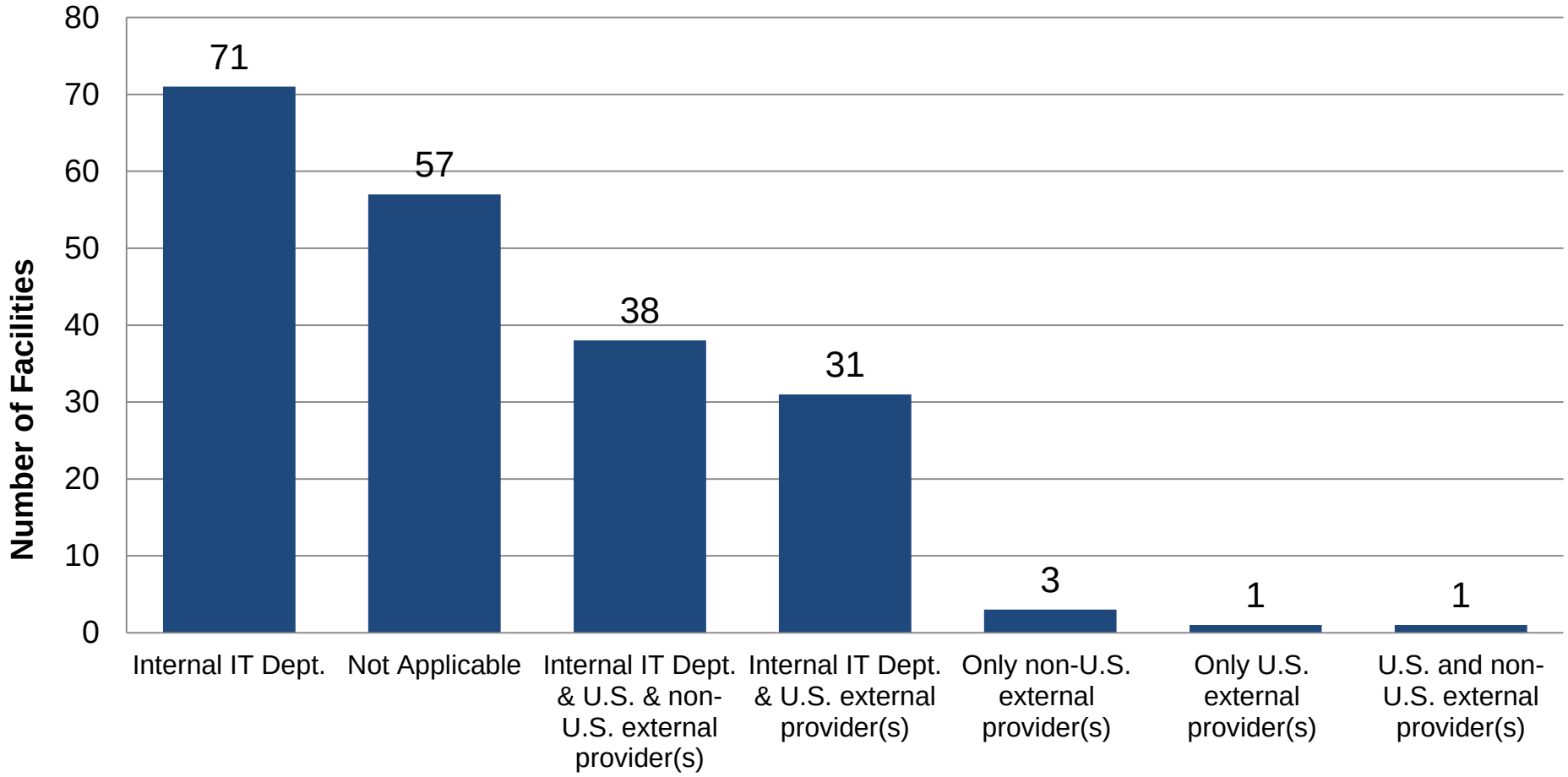
Q13a,B

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

202 respondents

Cyber Security
Management of External Networks (2015)

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



Q13a,B

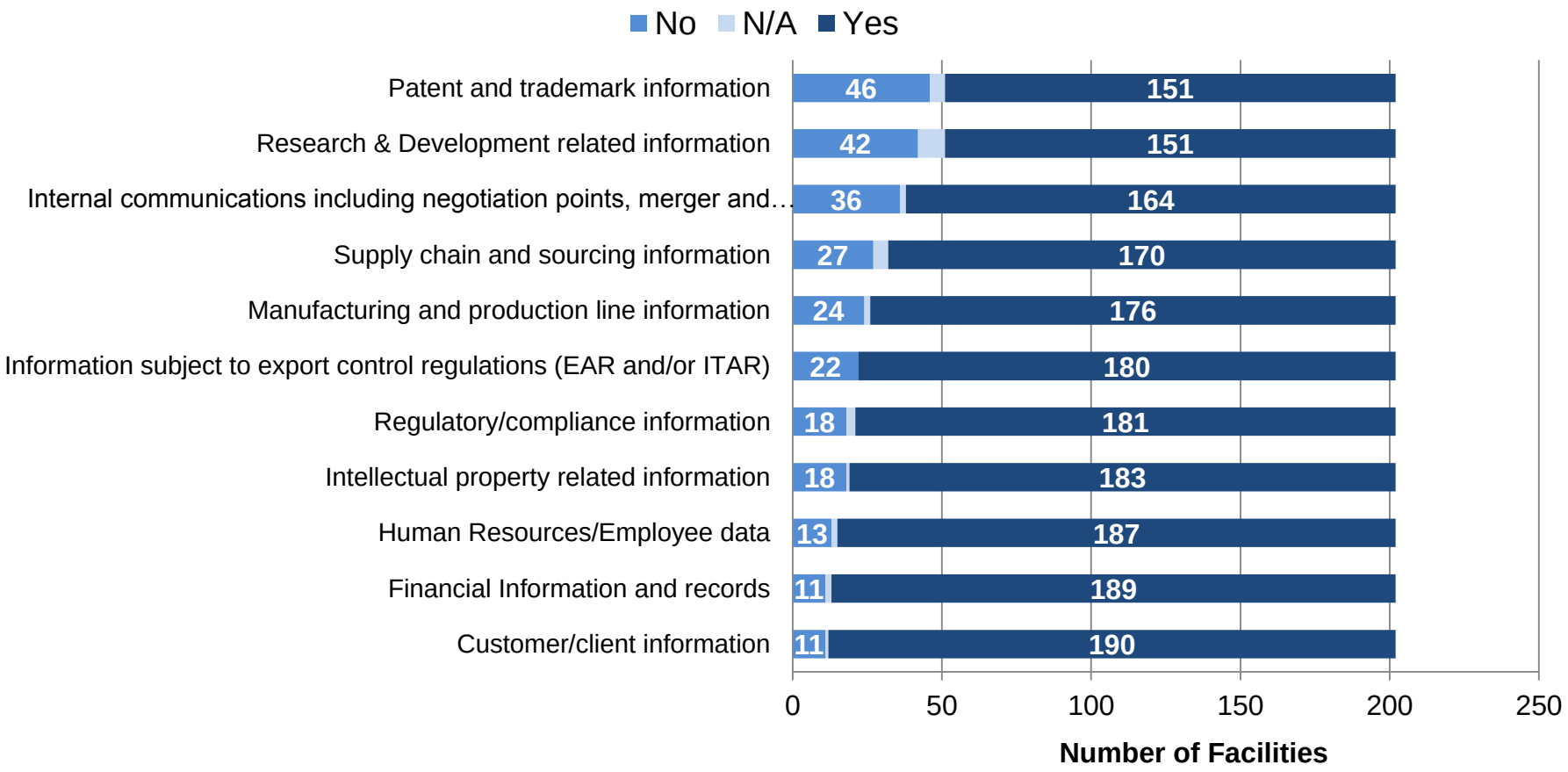
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

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?



Q13a,C

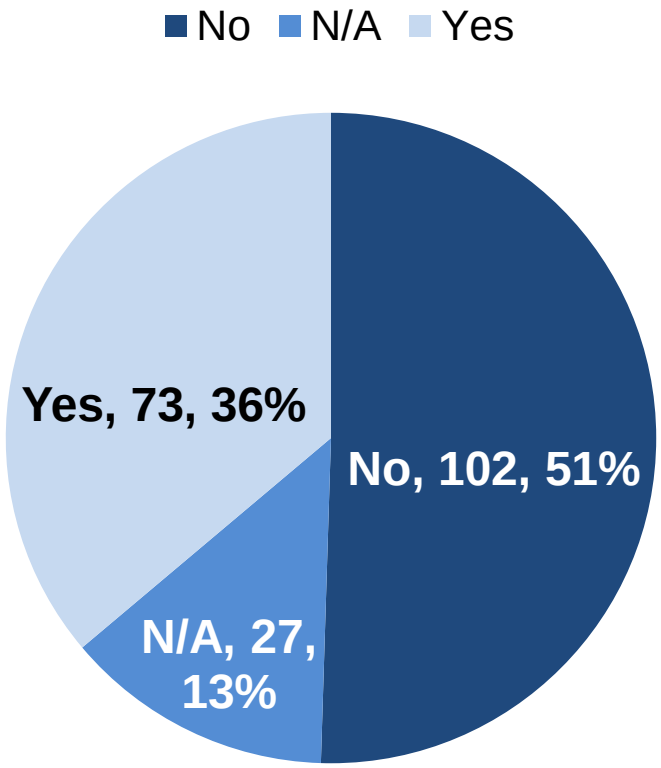
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

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?

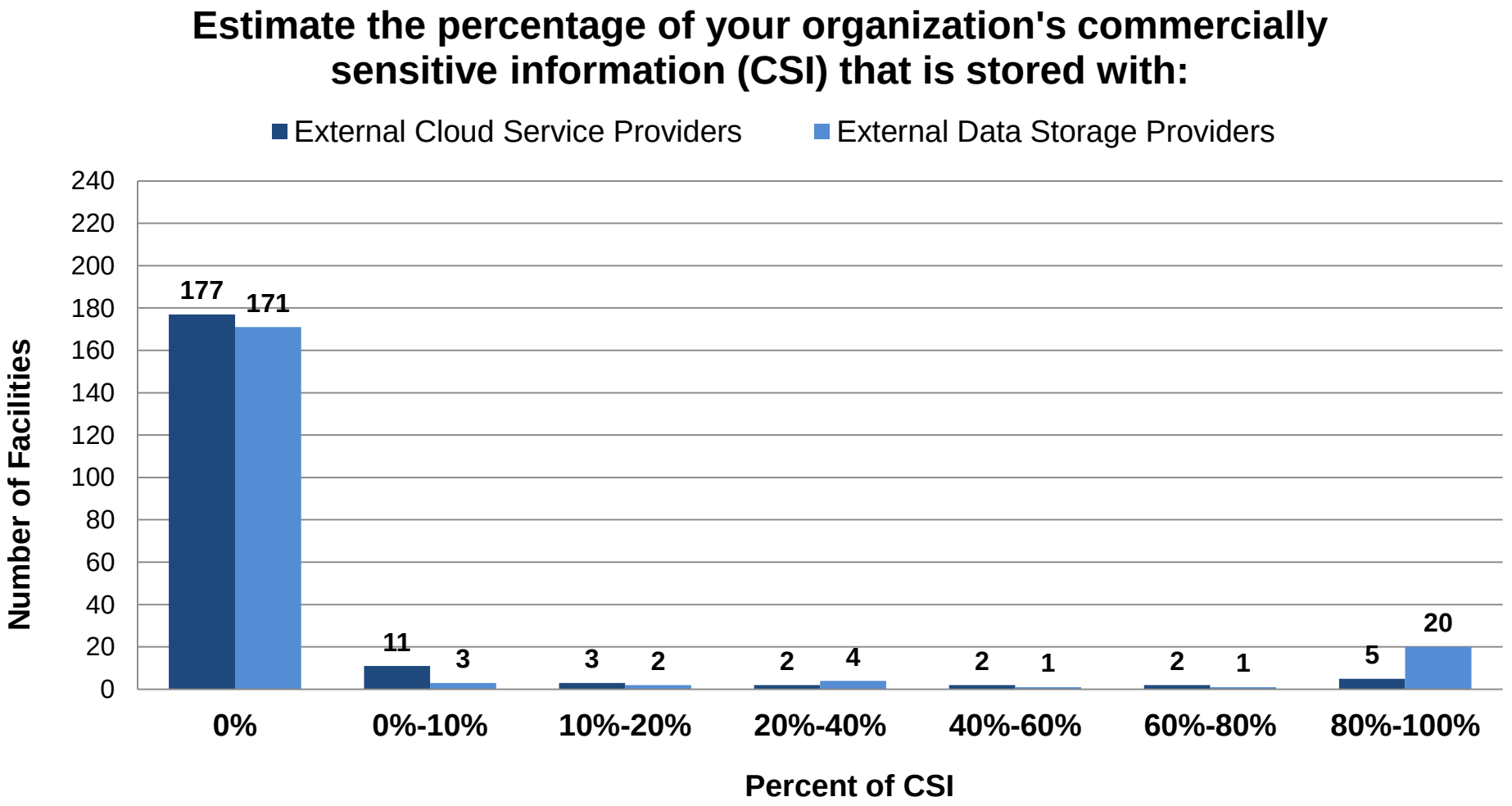


Q13b,A

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)



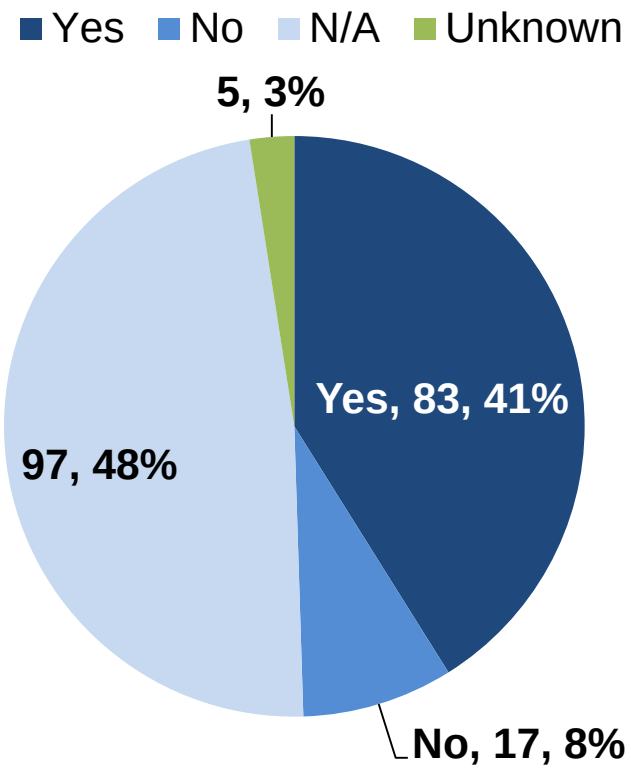
Q13b,B

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.?



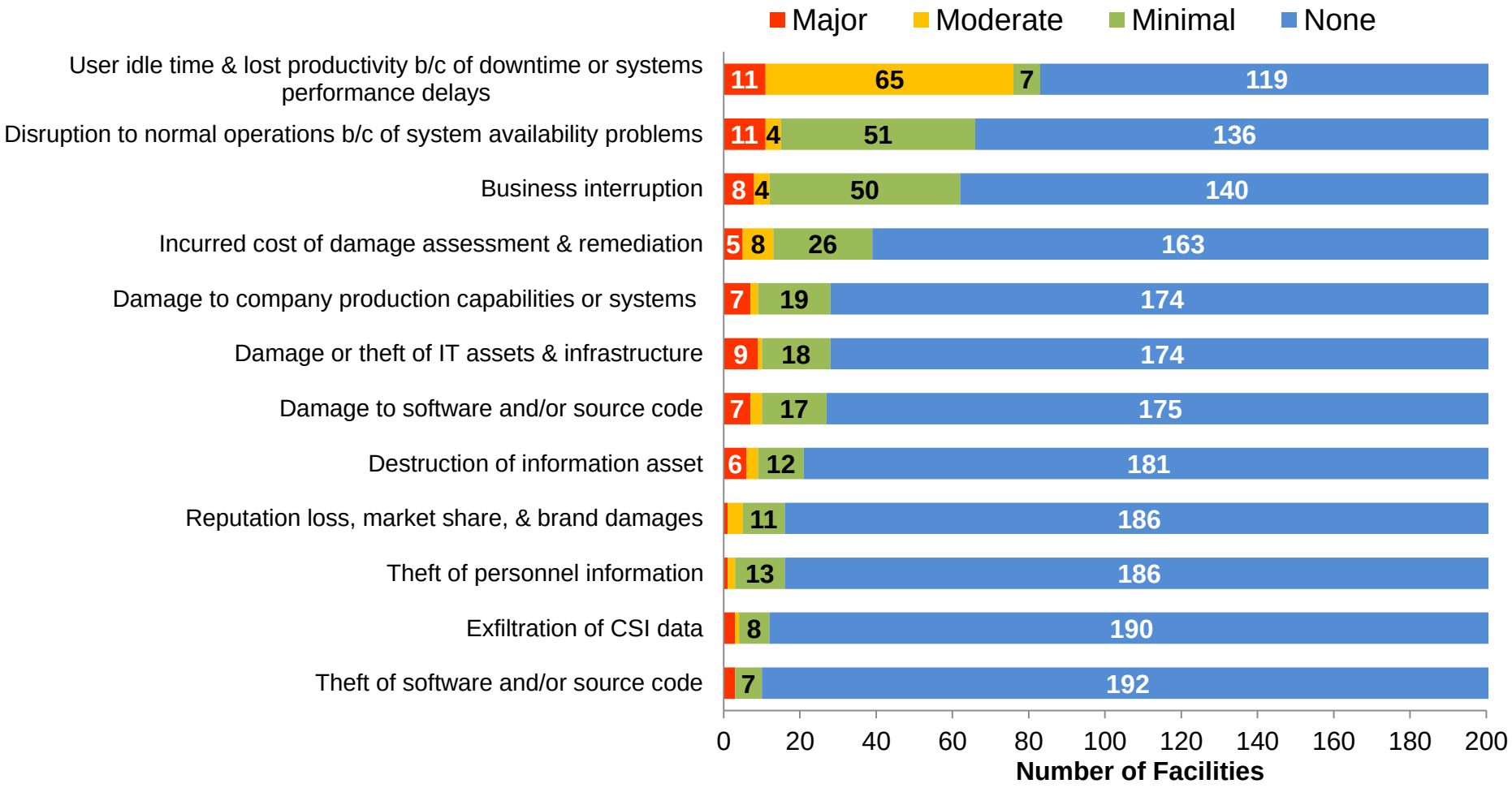
Q13b,B

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 Cyber Events (2012-2015)

Indicate the level of impact each of the following types of events attributed to malicious cyber activity has had on this facility since 2012.



Q13b,C

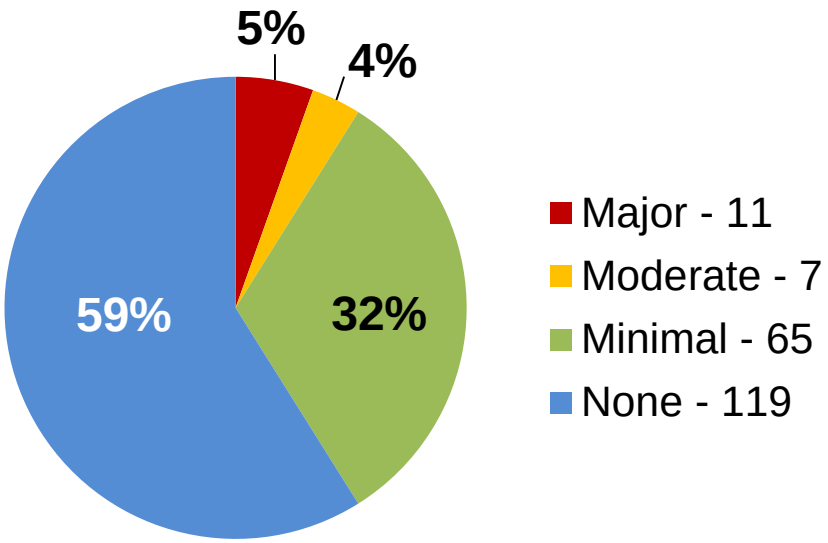
Source: U.S. Department of Commerce, Bureau of Industry and Security
U.S. Bare Printed Circuit Board Industry Assessment – 2017

202 respondents

Cyber Security – Idle Time Tied to Malicious Activity

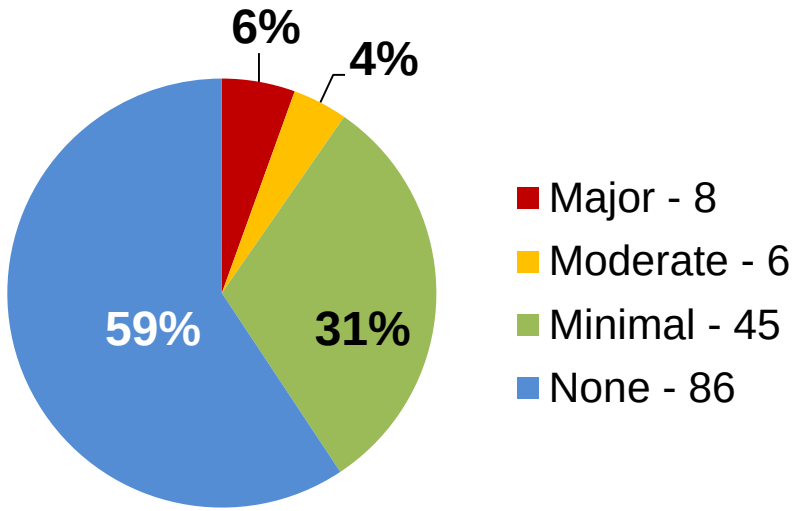
Levels of impact of idle time and lost productivity at U.S. Bare PCB manufacturing facilities attributed to malicious cyber activity (2012-2015)

All Bare PCB Facilities



202 Respondents

Bare PCB Facilities with Defense End Use Applications



145 Respondents

Q13a

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

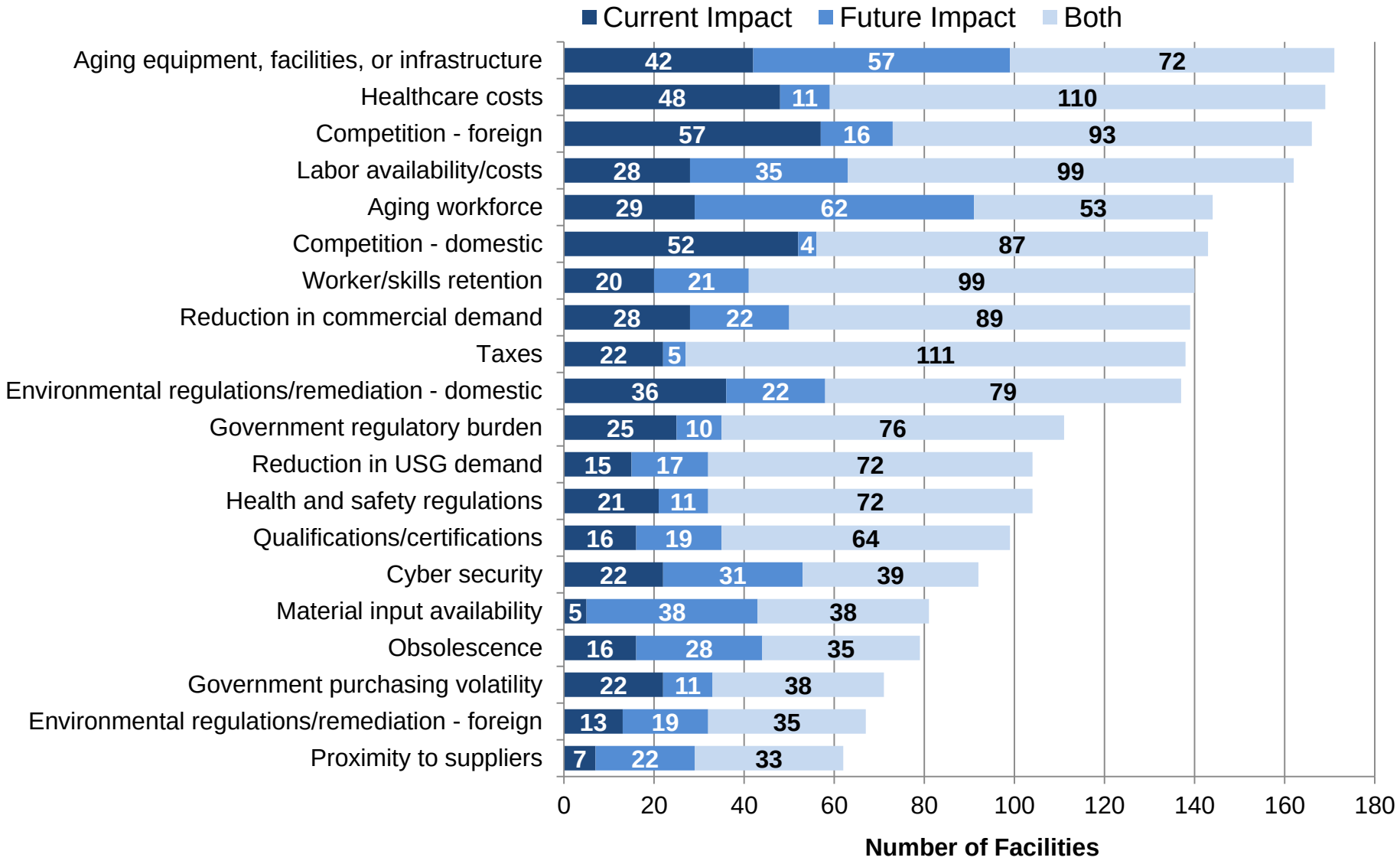
Cyber Security - General Industry Comments

- "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

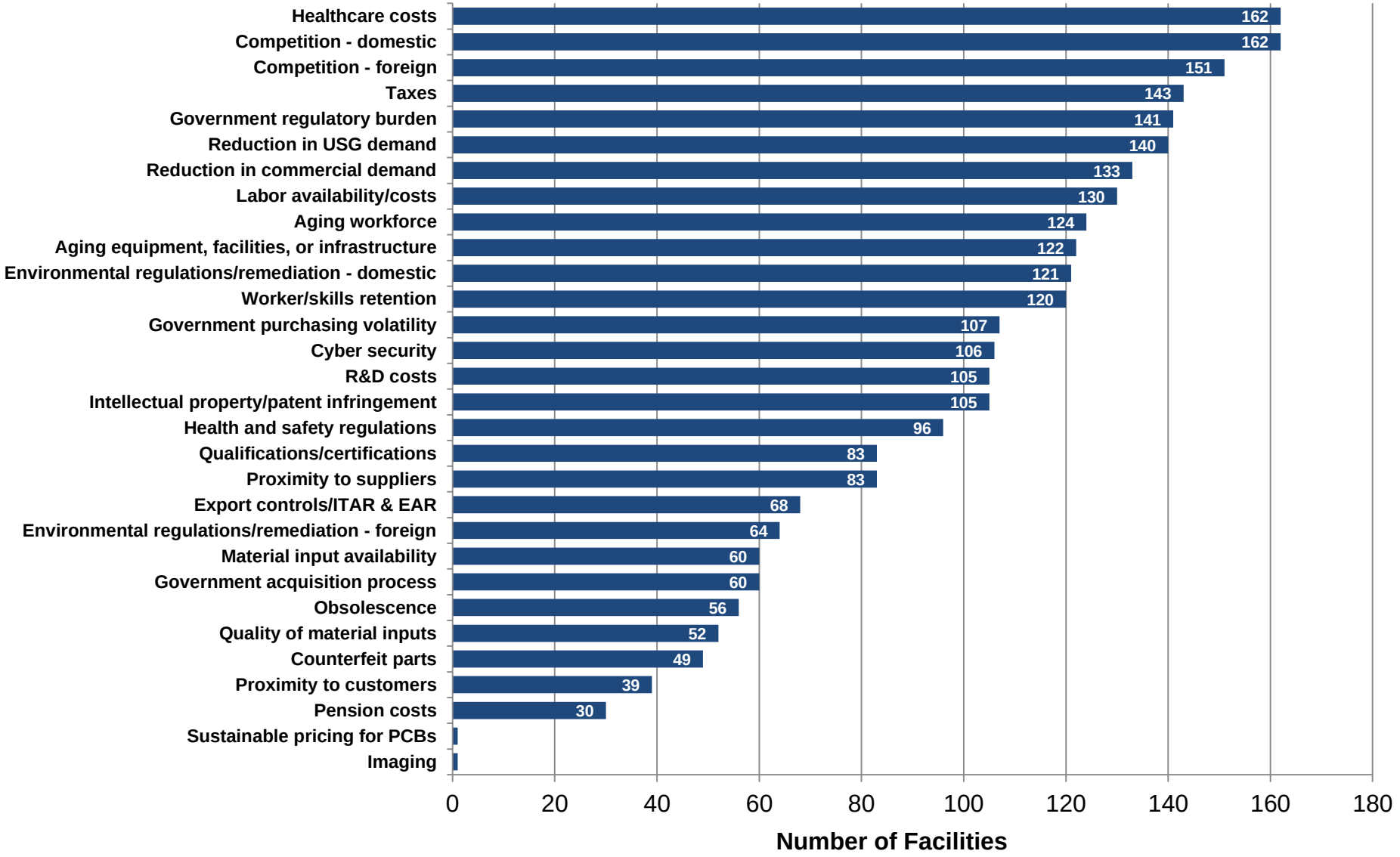


Q14, A

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

202 respondents

Challenges – Issues Affecting Bare PCB Producers

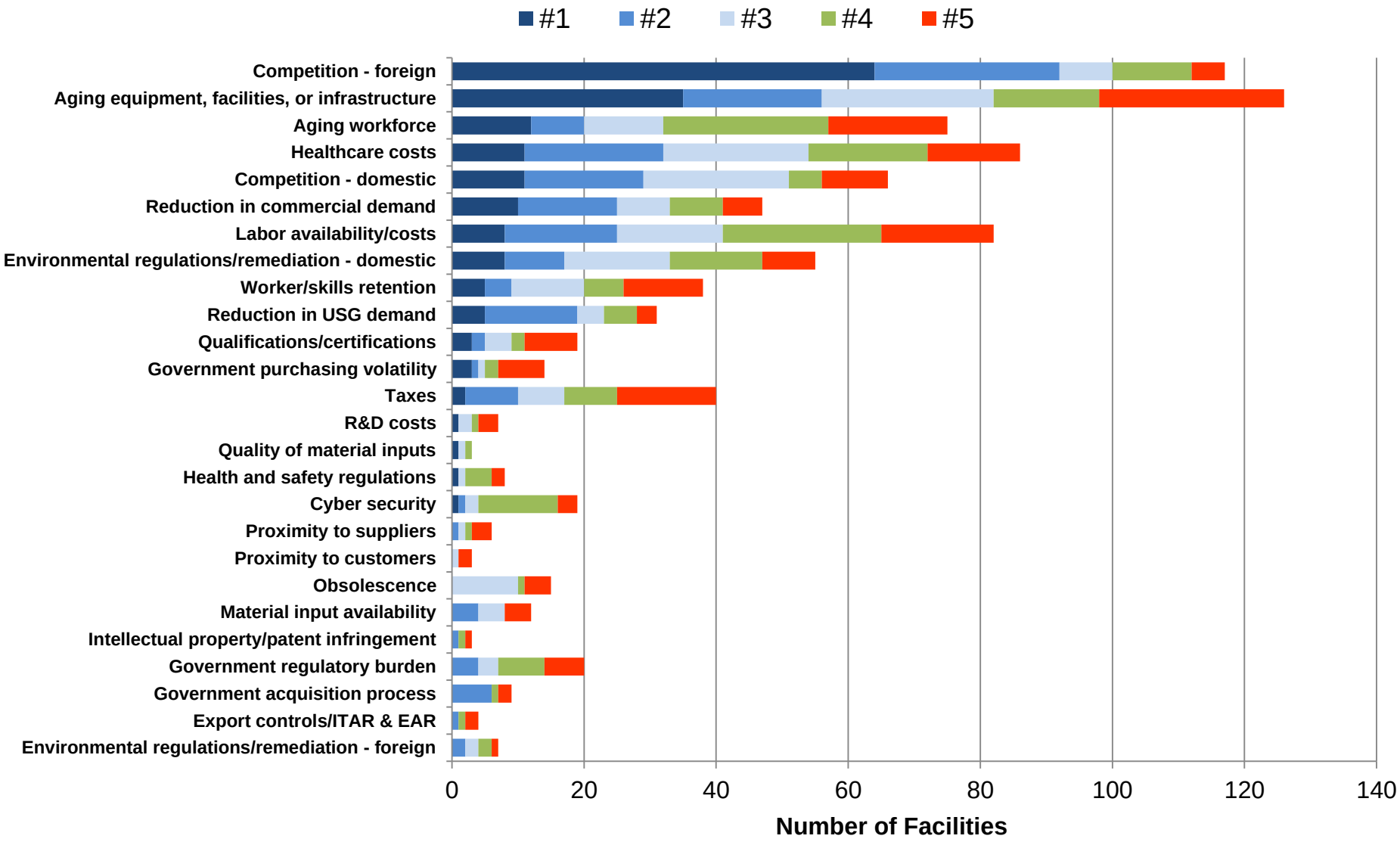


Q14, A

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

202 respondents

Challenges – Top 5 Ranked Bare PCB Industry Key Issues

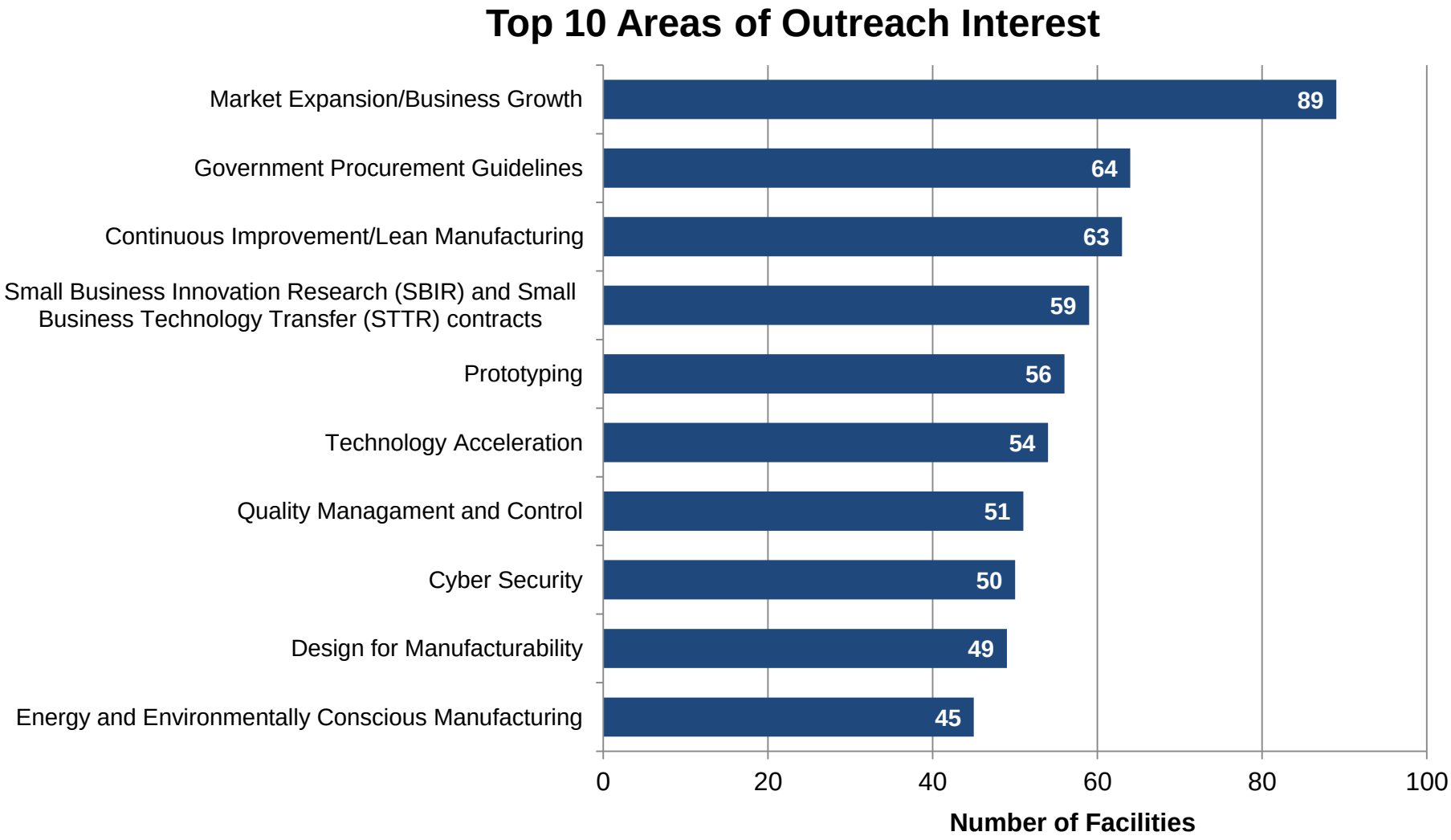


Q14, A

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

202 respondents

U.S. PCB Industry Interest in U.S. Government Outreach

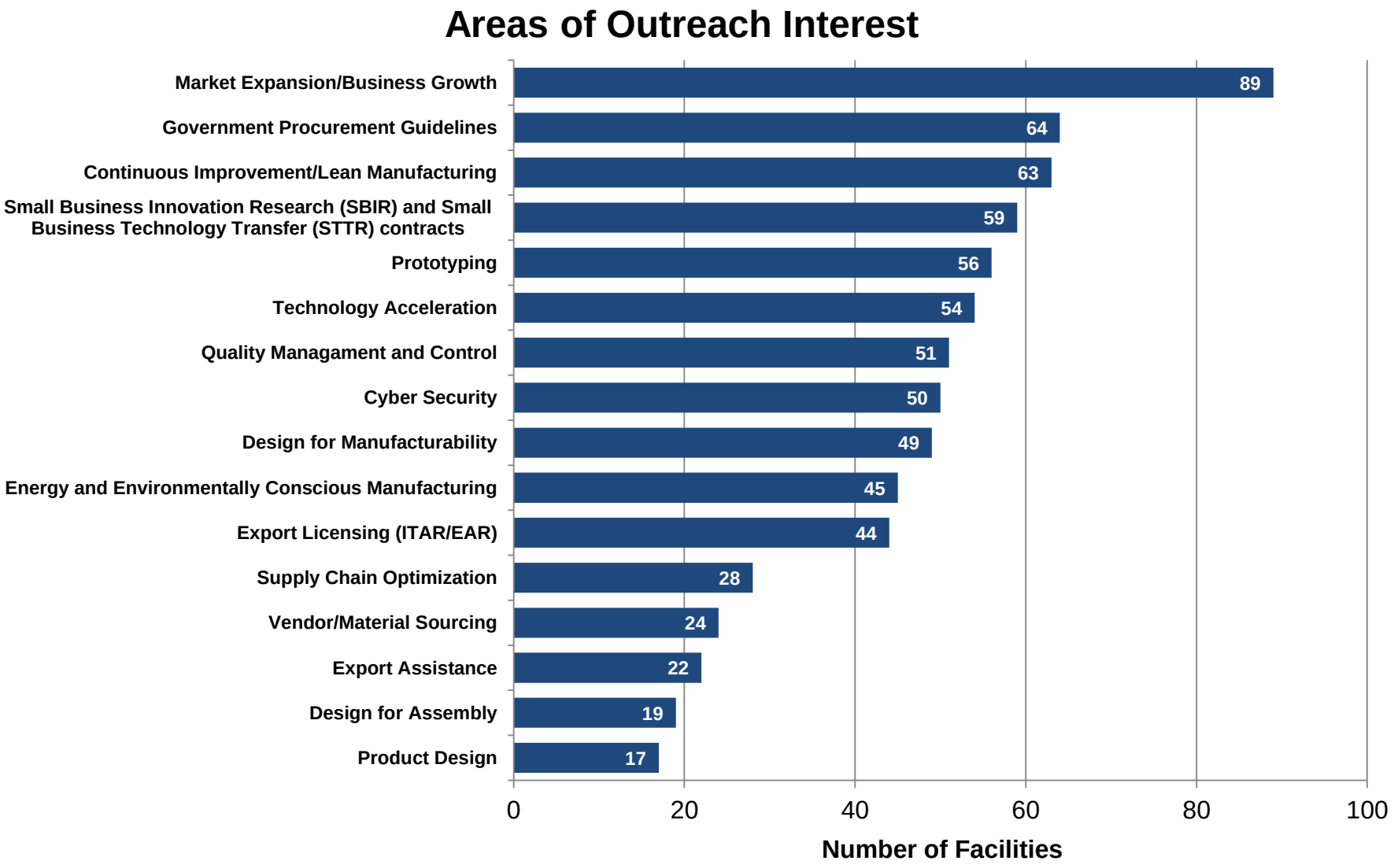


Q14,B

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



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…."

Q14, B

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

202 respondents

OMB Control Number: 0694-0119
Expiration Date: 12/31/2016

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.

Not withstanding 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

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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. 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. To arrange for the completed survey to be delivered on CD-ROM or DVD disc by private carrier, contact BIS survey staff.
F.	Questions related to this Excel survey should be directed to: printedcircuitboards@bis.doc.gov. 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.
G.	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.

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section II: Definitions

Term	Definition
Applied Research	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.
Authorizing Official	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.
Bare Printed Circuit Board	A completed, tested circuit board ready to be populated with components to create a working system.
Basic Research	Systematic, scientific study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts.
Board Thickness	The overall thickness of the base material, all conductive material deposited thereon, and solder mask.
Commercial and Government Entity (CAGE) Code	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 https://cage.dla.mil/search/begin_search.aspx .
Commercially Sensitive Information (CSI)	Privileged or proprietary information which, if compromised through alteration, corruption, loss, misuse, or unauthorized disclosure, could cause serious harm to the organization owning it.
Customer	Any organization (external or internal entity) for which your company manufactures bare circuit board products.
Data Universal Numbering System (DUNS)	A nine-digit numbering system that uniquely identifies an individual business. Find DUNS numbers at http://fedgov.dnb.com/webform .
Export Controls	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.
External Cloud Service Provider	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.
External Data Storage Provider	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.
Flex	A flexible circuit board with printed circuitry on flexible base material consisting of one or more layers.
Full Time Equivalent (FTE) Employees	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.
Microvia	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.
North American Industry Classification System (NAICS) Code	North American Industry Classification System (NAICS) codes identify the category of product(s) or service(s) provided by an organization. Find NAICS codes at http://www.census.gov/epcd/www/naics.html
Planarization	Planarization is a mechanical sanding/polishing process to create a flat or planar surface across copper conductor on circuit boards.
Pre-Preg	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.
Product/Process Development	Conceptualization and development of a product prior to the production of the product for customers.
Qualified Manufacturers' List (QML)	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.
Qualified Products List (QPL)	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.
Rigid	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.
Rigid-Flex	One or more rigid circuit boards connected by a flexible circuit board.
Service	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.
Single Source	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.
Sole Source	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.
Supplier	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.
United States	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.
Via	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.
Via Structure	A description of vias (including microvias) incorporated in a multilayer circuit board product.

Section III: Respondent Profile

A.	Select the description that best identifies your organization:	

Corporation
Non-Profit
University
USG Agency
Other

		Design Capability	Manufacture Capability	Assembly Capability
B.	What capabilities does this facility have related to the production of bare printed circuit boards?			

If your organization has multiple facilities in the United States that manufacture bare printed circuit boards you must provide separate survey responses for each facility. Indicate at right the description that best describes your organization's circuit board manufacturing structure. 1. Organization has a single facility, which is located in the U.S. 2. Organization has multiple facilities, but only one bare circuit board manufacturing facility in the U.S. 3. Organization has multiple facilities in the U.S. with bare circuit board manufacturing capabilities. If your organization does not manufacture bare printed circuit boards in the U.S., contact BIS survey staff at printedcircuitboards@bis.doc.gov.	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 1a: Organization Information

A.	Provide the following information for this facility.	
	Facility/Organization Name	
	Street Address	
	City	
	State	
	Zip Code	
	Website	
	Phone Number	
	Primary CAGE Code	

B.	Provide the following information for your parent organization(s), if applicable. If not applicable, insert "NA" in the Parent Name box.	
		Parent Organization
	Parent Name	
	Street Address	
	City	
	State/Province	
	Country	
	Postal Code/Zip Code	
	Parent Primary CAGE Code	

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:				
	Name	Title	Phone Number	E-mail Address	State

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 1b: Organization Information (continued)

A. 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):

Entity Name	Percent of Company Held	Street Address	City	State/Region	Country

B. Please provide the following identification codes (see definitions), as applicable, to this facility.

Data Universal Numbering System (DUNS) Code(s)		NAICS (6-digit) Code(s)	
Find DUNS numbers at: http://fedgov.dnb.com/webform		Find NAICS codes at: http://www.census.gov/epcd/www/naics.html	

C. 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

Section 1c: Organization Information (continued)

A.	Estimate the percentage of this facility's bare printed circuit board sales attributable to COMMERCIAL end uses:		
	Estimate the percentage of this facility's bare printed circuit board sales attributable to DEFENSE end uses:		

Commercial Market Segments

From the list below, estimate the percentage of this facility's bare circuit board sales attributable to each COMMERCIAL end use.

	Commercial End Use	% of Bare Circuit Board Sales	Commercial End Use		% of Bare Circuit Board Sales
B.	Aerospace		Industrial Electronics		
	Automotive		Medical/Healthcare		
	Communications		Marine (surface and underwater)		
	Computers/Business Equipment		Space		
	Consumer Goods		Other	(specify here)	

Defense Market Segments

From the list below, estimate the percentage of this facility's bare circuit board sales attributable to each DEFENSE end use.

	Defense End Use	% of Bare Circuit Board Sales	Defense End Use		% of Bare Circuit Board Sales
C.	Aerospace		Missiles		
	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)		Marine (surface and underwater)		
	Electronics		Space		
	Ground Vehicles		Other	(specify here)	

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 2: Mergers, Acquisitions, Divestitures, and Joint Ventures

Mergers, Acquisitions, Divestitures

How many mergers, acquisitions, and divestitures has your organization had since 2012?

Identify and describe your organization's five most recent mergers, acquisitions, and divestitures, if applicable.

A.

	Organization Name	Type of Activity	Country	Year	Primary Objective	Explain
1.						
2.						
3.						
4.						
5.						

Primary Objective:
- Access to government contracts
- Access to intellectual property
- Bankruptcy restructuring/litigation
- Broaden customer base
- Develop new capabilities
- Overcome market entry barrier/Geopolitical concerns
- R&D access/coordination
- Reduce Costs
- Tax-related
- Vertical integration
- Other objective/purpose (Explain)

Joint Ventures

How many joint ventures does your organization currently participate in?

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.):

B.

	Organization/Entity Name	Country	Year Initiated	Primary Purpose of Relationship	Explain
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

Primary Purpose of Relationship:
- Access to financial resources
- Access to suppliers
- Access to technological resources
- Creation of new technologies
- Improved access to foreign markets
- Improved access to U.S. markets
- Product improvements
- Reduced costs
- Reduced lead times
- Risk sharing
- Shared/improved technology or skills
- Other objective/purpose (Explain)

Comments:

Section 3a: Customers

A. Select the primary method this facility uses to find business opportunities with the U.S. Government:

Prime contractors
Federal web site
DOD Queries
Word of Mouth
Other

Explain:

B. Since 2012 has this facility rejected business opportunities due to any of the following?

	-Yes/No-	Explain
Circuit board panel production run too small		
Insufficient order frequency		
Insufficient dollar value of job		
Insufficient dollar value of recurring business opportunity		
Complexity of job		
Customer credit rating		
Additional work not needed		
Other criteria (specify here)		

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

	Customer Name	Type of Customer	Primary End Use	Customer City	Customer State
1.					
2.					
3.					
4.					
5.					

Commercial
Government Defense
Government Non-Defense
University/Non-Profit
Other

Top Non-U.S.-Based Customers

	Customer Name	Type of Customer	Primary End Use	Customer City	Customer Country
1.					
2.					
3.					
4.					
5.					

Aerospace
Automotive
C4ISR
Communications
Computers/Business Equipment
Consumer Goods
Electronics
Ground Vehicles
Industrial Electronics
Marine (surface and underwater)
Medical/Healthcare
Missiles
Space
Other

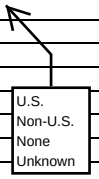
Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Pro

Section 3b: Competitors

A. 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.

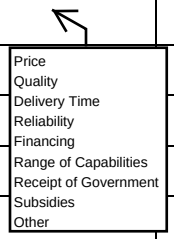
Factor	Location with Advantage	Explain
Labor Costs		
Environmental Compliance Costs		
Material Costs		
Equipment Costs		
Building Space Costs		
R&D Costs		
Supply of Skilled Workers		
Export Controls		
Overall Finished Board Price		
Quality		
Performance		
Lead Time		
Reduced Process Variability		
Reduced Cost		
Safety Requirements		
Increased Yield		
Other (specify here)		
Other (specify here)		



B. 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

	Competitor Name	State	Primary Competitive Attribute	Explain
1				
2				
3				
4				
5				



Top Non-U.S. Competitors

	Competitor Name	Country	Primary Competitive Attribute	Explain
1				
2				
3				
4				
5				

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 4a: Participation in USG Programs

USG Agency Support

A. 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.

U.S. Air Force		Department of Homeland Security (DHS)		Other	(select from dropdown)	
U.S. Army		National Aeronautics & Space Administration (NASA)		Other	(select from dropdown)	
U.S. Navy		National Oceanic & Atmospheric Administration (NOAA)		Other	(select from dropdown)	
U.S. Marine Corps		Department of Energy (DOE)		Other	(specify here)	
U.S. Intelligence Community (such as CIA, NGA, NRO, NSA)		Missile Defense Agency (MDA)		Other	(specify here)	

Direct
Indirect
Both
None
Unknown

USG Program Identification

B. Estimate the total number of USG programs this facility has directly or indirectly supported since 2012.

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.

	USG Program Name	U.S. Government Agency	Bare Circuit Board Type Supporting USG Program		
			Rigid	Flex	Rigid-Flex
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

U.S. Air Force
U.S. Army
U.S. Navy
U.S. Marine Corps
U.S. Intelligence Community (such as CIA, NGA, NRO, NSA)
DHS - Department of Homeland Security
NASA - National Aeronautics & Space Administration
NOAA - National Oceanic & Atmospheric Administration
DOE - Department of Energy
MDA - Missile Defense Agency
DARPA - Defense Advanced Research Projects Agency
USDA - Department of Agriculture
DOC - Department of Commerce
HHS - Department of Health and Human Services
State Department
Justice Department
Transportation Department
EPA - Environmental Protection Agency
FCC - Federal Communications Commission
NRC - Nuclear Regulatory Commission
VA - Department of Veterans Avvairs
White House
Other

Yes
No

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 4b: USG Interactions

A.

Does this facility consider itself dependent on U.S. Government programs for its continued viability?	Yes / No
Explain	
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?	Integrated / Separate / Not Applicable
Explain	

B. Identify impacts that a sudden change in direct and/or indirect U.S. Government defense demand for electronic products containing bare circuit boards would likely have on your organization and provide an explanation where applicable.

Business Operation	Impact of sudden DECREASE in USG Defense Demand	Impact of sudden INCREASE in USG Defense Demand	Explanation
Capital Expenditures			
Research & Development Expenditures			
Participation in USG Contracts			
Product/Service Costs			
Organization Viability/Solvency			
Personnel with Key Skills			
Number of Product/Service Lines			
Pursuit of Non-U.S. Customers			
Level of Key Production Equipment			
Movement of Operations to Non-U.S. Locations			
Other (specify here)			
Other (specify here)			

Increase / No Change / Decrease / Not Applicable

Comments:

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Section 5a: Manufacturing Capabilities

A. Identify the types of bare circuit boards that this facility is currently capable of manufacturing:

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

Yes / No

Yes / No

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

Less than 0.001" / 0.001" / 0.002" / 0.003" / 0.004" / 0.005" / More than 0.005"

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

Less than 0.01" / 0.01" / 0.02" / More than 0.02"

C. Does this facility manufacture printed electronics (PE)?

"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 component, sensors, and others.

If yes, identify the PE business activities this facility engages in: — Explain:

If yes, identify the PE business sectors this facility supports: — Explain:

R&D Only / Limited Production / Full Production / Other (explain)

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:

	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
External Layer: Standard							
External Layer: Minimum							
Internal Layer: Standard							
Internal Layer: Minimum							

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:

	Space 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
External Layer: Standard							
External Layer: Minimum							
Internal Layer: Standard							
Internal Layer: Minimum							

Less than 0.001" / 0.001" / 0.002" / 0.003" / 0.004" / 0.005" / More than 0.005"

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 5b: Manufacturing Capabilities (continued)

A. Identify the bare circuit board manufacturing processes that this facility is capable of employing:

Process	Capable of Using	Currently Use	Process	Capable of Using	Currently Use
Photo imaging			Thermal management structures		
Direct imaging			Automated electroless copper plating		
Screen printing			Automated electrolytic copper plating		
Controlled drilling/milling			Direct metallization plating		
Laser ablation			Hot air solder level tin-lead		
Fully additive plating			Hot air solder level lead-free		
Z-axis interconnect technology			LPI solder mask		
Embedded devices (e.g. resistors, capacitors, etc.)			Dry film solder mask		
Opto-electronic structures			Other (specify here)		

Yes
No
Not Applicable

B. Identify this facility's maximum capability for each of the following bare circuit board production factors:

Factor	Maximum per Board	Explanation
Circuit layers		
Sequential laminations		
Impedance structures		
Stacked micro vias		
Staggered micro vias		

C. Identify where the bare circuit board via fill and planarization manufacturing activities are performed for this facility:

	-Yes/No-	Process Method	Explanation
This facility			
Other company-owned U.S. facilities			
Other company-owned non-U.S. facilities			
Contractor-operated U.S. facilities			
Contractor-operated non-U.S. facilities			

Yes
No
Not Applicable

Manual
Automatic
Both
Neither
Not Applicable

D. Identify which of following processes associated with via structures this facility is capable of performing:

Via Formation	-Yes/No-	Via Formation	-Yes/No-	Drilling Process	Maximum aspect ratio
Etchback		Plasma etch		Laser-formed micro via	
Chemical smear removal		Laser via formation		Mechanically drilled via: through-board	
Micro-via solid copper fill		Nonconductive via fill		Mechanically drilled via: controlled-depth	

Under 0.5:1
0.5:1
0.75:1
1:1
Over 1:1

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 5c: Manufacturing Standards

A. Identify the standards that this facility currently employs and indicate whether you have a formal certification or apply the standards informally.

Standard		Use	Explain
MIL-PRF 55110			
MIL-PRF 50884			
MIL-PRF 31032			
ISO 9001			
AS 9100			
NADCAP			
IPC 1071			
IPC 6011			
IPC 6012			
IPC 6013			
IPC 6015			
IPC 6016			
IPC 6017			
IPC 6018			
Other	(specify here)		
Other	(specify here)		

Formal Certification
Informal Use
Not Used

B. Does this facility have an active technical review board? ____

Explain: ____

C. Identify the primary final circuit board inspection method this facility uses to assure that manufactured products meet performance requirements. ____

C=0
Sampling
100% Inspection
Other

Are first article inspection capabilities at this facility compliant with AS 9102? ____

Explain: ____

D. Identify the forms of testing that this facility uses in manufacturing to assure performance and adherence to operational requirements.

Testing Form	-Yes/No-	Testing Form	-Yes/No-
Flying Probe		Impedance Testing with Plots	
Bed-of-Nails		Interconnect Stress Testing (IST)	
Isolation 250 Volts DC, 100 MegaOhm Minimum		Highly Accelerated Stress Testing (HAST)	
Continuity 10 Volts DC, 10 Ohm Maximum		Highly Accelerated Life Testing (HALT)	
Test all end points, no phase testing		Highly Accelerated Thermal Shock (HATS)	

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? ____

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

A. 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:

Inner Layer (Core):
A sheet of copper clad dielectric with one or both sides bearing circuit patterns.

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).

	2012	2013	2014	2015
Average Weekly Inner Layers (Cores) Manufactured				
Average Weekly Panels Manufactured				

B. Identify the bare circuit board panel sizes that this facility can produce with its current manufacturing equipment:

Panel Size:	24x36	24x30	21x24	18x24	12x24	12x18	9x12	Other
Capability:								
Explain:								

Yes
No

C. Estimate the 2015 rated weekly manufacturing capacity of this facility in units:

Inner Layers (Cores)	Panels

D.

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?	
Explain:	

E. 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

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.

2012	2013	2014	2015

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

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.

	Factor	Scenario: 100%	Scenario: 150%	Explanation
1	Amount of equipment			
2	Availability of equipment			
3	Manufacturing space			
4	Availability or cost of workforce			
5	Quality control			
6	Availability of input materials			
7	Other (specify in explanation)			

Comments:

Section 5e: Manufacturing Production & Capacity (continued)

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

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

Increase
No Change
Decrease
Not Applicable

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

End Use	Anticipated Change	Explain
Commercial		
Defense		

Increase
No Change
Decrease
Not Applicable

C.

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?	
3	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?	

3 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:

End Use	-Yes/No-	Country 1	Country 2	Country 3
Commercial				
Defense				

D. Identify the three biggest factors causing production bottlenecks at this facility.

1		Explain:	
2		Explain:	
3		Explain:	

Automated optical inspection (AOI)
Drilling
Electroless plating
Electrolytic plating
Electrical test
Etching
Front end engineering
Inner layer pretreatment
Imaging
Lamination
Other

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 6a: Materials & Equipment

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.

	Material		Total Number of Manufacturers Used	Sourcing Problems		Manufacturers		
				Availability is a Concern	Experienced Supply Chain Disruptions Since 2012	Two Principal Manufacturer Names		Country of Manufacture
A.	Laminate for use in rigid conventional boards					1		
						2		
	Laminate for use in rigid multilayer boards					1		
						2		
	Laminate for use in rigid high speed, high frequency, and microwave boards					1		
						2		
	Laminate for use in flex boards					1		
						2		
	Laminate for use in rigid-flex boards					1		
						2		
	Copper foil					1		
						2		
	Other foils					1		
						2		
	Embedded passives, formed, resistors, and capacitors (active or passive) - tin-lead					1		
						2		
	Embedded passives, formed, resistors, and capacitors (active or passive) - lead free					1		
						2		
	Through-hole and via preparation for plating material					1		
						2		
	Electrolytic plating material					1		
						2		
	Via fill, conductive, and non-conductive material					1		
						2		
	Solder mask					1		
						2		
	Finish materials					1		
						2		
	Solder					1		
						2		
	Etchant					1		
						2		
	Drill bits					1		
						2		
	Other	(specify here)				1		
						2		

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 6b: Materials & Equipment (continued)

A.	1	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?	
	2	How many weeks would it take this facility to obtain material from a new supplier of laminate?	
	3	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?	
		Explain:	
	4	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?	← Very confident / Somewhat confident / Not confident / Would not be able to
		Explain:	
B.		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?	
			← 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.
		Explain:	
C.		Does this facility use either of the following practices for assuring the availability of circuit board-related materials?	
	1	On-site stocking agreements through which distributors/manufacturers keep a quantity of materials at this facility.	
	2	Local stocking agreements through which distributors/manufacturers maintain supply warehouses in close proximity to this facility.	
		Explain:	
		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

	Equipment		Number of Functioning Units On Site	Estimated Average Age (in years)	Primary Concern	Explain
A.	Photo film processing					
	Photo resist application					
	Photo resist exposure					
	Photo resist exposure-laser					
	Photo resist exposure-LED					
	Develop etch & strip equipment					
	Automatic optical inspection					
	Inner layer treatment & layup					
	Lamination					
	Drilling - mechanical					
	Drilling - laser					
	Desmear					
	Electroless copper					
	Electrolytic copper					
	Chemical cleaning					
	Solder mask					
	Final finish					
	Legend print					
	Routing					
	Electrical testing					
	Quality control measurement					
	Via fill					
	Scoring					
	Other	(specify here)				
	Other	(specify here)				
	Other	(specify here)				

Availability
Cost to replace
Time to replace
Upgradeability
Service
Spare parts
Other
None

		U.S.	Non-U.S.	Explanation
B.	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?			
C.	Are there bare circuit board products that this facility is unable to manufacture due to the limitations of installed equipment?		Explain:	
	Have you had or do you anticipate having difficulty obtaining new equipment for manufacturing tin-lead bare circuit boards?		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.				
	Prepreg			Explain:	
	Laminate			Explain:	
	Soldermask			Explain:	
	Other	(specify here)		Explain:	

Confirmed
Suspected
Both
No

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.

Facility
Division/Business Unit
Corporate/Whole Organization

Source of Sales Data:

Reporting Schedule:

Calendar Year
Fiscal Year

Record in $ Thousands, e.g. $12,000.00 = survey input $12

		2012		2013		2014		2015	
		U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.	U.S.	Non-U.S.
A.	Total Sales (in $)								
	Total Government Sales [as a % of line A]								
B	All Circuit Board-Related Sales - including design, manufacture, and assembly (in $)								
	All Circuit Board-Related Government Sales [as a % of line B]								
C	Bare Circuit Board Manufacturing Sales - excluding design and assembly (in $)								
	Bare Circuit Board Government Sales [as a % of line C]								

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.

Source of Income Statement Items:	
Reporting Schedule:	

Facility
Division/Business Unit
Corporate/Whole Organization

Calendar Year
Fiscal Year

Income Statement (Select Line Items)		Record $ in Thousands, e.g. $12,000.00 = survey input of $12			
		2012	2013	2014	2015
A.	Net Sales (and other revenue)				
B.	Cost of Goods Sold				
C.	Total Operating Income (Loss)				
D.	Earnings Before Interest and Taxes				
E.	Net Income				

Source of Balance Sheet Items:	
Reporting Schedule:	

Facility
Division/Business Unit
Corporate/Whole Organization

Calendar Year
Fiscal Year

Balance Sheet (Select Line Items)		Record $ in Thousands, e.g. $12,000.00 = survey input of $12			
		2012	2013	2014	2015
A.	Cash				
B.	Inventories				
C.	Total Current Assets				
D.	Total Assets				
E.	Total Current Liabilities				
F.	Total Liabilities				
G.	Retained Earnings				
H.	Total Owner's Equity				

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)?		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.

Facility
Division/Business Unit
Corporate/Whole Organization

	Source of R&D Data:	
	Reporting Schedule:	

Calendar Year
Fiscal Year

B.

		Record $ in Thousands, e.g. $12,000.00 = survey input of $12			
		2012	2013	2014	2015
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%)	0%	0%	0%	0%
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)				

C.

		Record $ in Thousands, e.g. $12,000.00 = survey input of $12			
		2012	2013	2014	2015
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)

A. Identify this facility/organization's anticipated top R&D priorities over the next five years and provide a brief explanation.

	Priority	Description
1		
2		
3		
4		
5		

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

B. 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.

Factor		-Yes/No-	Explain
Need for competitive advantage			
Customer requirements			
Industry roadmap			
Other	(specify here)		
Other	(specify here)		
Other	(specify here)		

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

Explain:

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

Explain:

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

1		Explain:	
2		Explain:	
3		Explain:	

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

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

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.

Facility
Division/Business Unit
Corporate/Whole Organization

Source of Capital Expenditure Data:	
Capital Expenditure Reporting Schedule:	

Calendar Year
Fiscal Year

	Capital Expenditure Category	Record $ in Thousands, e.g. $12,000.00 = survey input of $12			
		2012	2013	2014	2015
A	Total Capital Expenditures				
1	Machinery, Equipment, and Vehicles [as a % of A]				
2	IT, Computers, Software [as a % of A]				
3	Land, Buildings, and Leasehold Improvements [as a % of A]				
4	Other (specify)				
5	Other (specify)				
	Lines 1 through 5 must total 100%	0%	0%	0%	0%
6	Bare circuit board-related capital expenditures [as a % of A]				

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.

	Priority	Description
1		
2		
3		
4		
5		

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

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 11a: Workforce

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.

		Source of Workforce Data:				
		Reporting Schedule:				
A	1	Circuit Board-Related Full Time Equivalent (FTE) Employees	2012	2013	2014	2015
	a	Administrative, Management, & Legal Staff [as a % of line 1]				
	b	Engineers, Scientists, and R&D Staff [as a % of line 1]				
	c	Facility & Maintenance Staff [as a % of line 1]				
	d	Information Technology Professionals [as a % of line 1]				
	e	Marketing & Sales [as a % of line 1]				
	f	Production Line Workers [as a % of line 1]				
	g	Testing Operators, Quality Control, and Support Technicians [as a % of line 1]				
	h	Other (specify here)				
	i	Other (specify here)				
		Lines a through i must total 100%	0%	0%	0%	0%

Facility
Division/Business Unit
Corporate/Whole Organization

Calendar Year
Fiscal Year

Does this facility have difficulty hiring and/or retaining any types of employees?
If yes, identify which occupations, type of difficulty, and provide an explanation.

B	Occupation	Difficulty	Explanation
	Chemist		
	Chemical Engineer		
	Electrical Engineer		
	Mechanical Engineer		
	Industrial Engineer		
	Safety Engineer		
	Graphic Arts Engineer		
	Process Engineer		
	Product Engineer		
	CAM Software - Job Tooling Tech		
	Imaging Tech		
	Silk Screening Tech		
	Plating Tech		
	Electrical Testing Tech		
	Mechanical Drilling Tech		
	Laser Drilling Tech		
	Testing Tech		
	Other (specify here)		

Hiring
Retaining
Both
No

Identify the key workforce issues you anticipate in the next five years.

C	Issue	-Yes/No-	Explanation
	Finding U.S. citizens		
	Finding qualified workers		
	Finding experienced workers		
	Finding workers able to get security clearances		
	Attracting workers to location		
	Significant portion of workforce retiring		
	Employee turnover		
	Other (specify here)		
	Other (specify here)		

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?		
	What percentage of this facility's technical staff do you expect to have to replace over the next five years?		
	Explain:		

B

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.

		Applicable Working Experience			
		Over 20 Years	11-20 Years	6-10 Years	Five or Fewer Years
All Employees	# of Employees				
	% U.S. Citizens				

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.

Experience:	Over 20 Years	11-20 Years	6-10 Years	Five or Fewer Years
	# of Employees	# of Employees	# of Employees	# of Employees
Chemist				
Chemical Engineer				
Electrical Engineer				
Mechanical Engineer				
Industrial Engineer				
Safety Engineer				
Graphic Arts Engineer				
Process Engineer				
Product Engineer				
CAM Software - Job Tooling Tech				
Imaging Tech				
Silk Screening Tech				
Plating Tech				
Electrical Testing Tech				
Mechanical Drilling Tech				
Laser Drilling Tech				
Testing Tech				
Other (specify here)				

Comments:	

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:		

None
Expansion
Modernization
Contraction
Potential Closure
Other

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:			
	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:	
	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.

Factor		Reduce Interest in USG Business	May Cause Facility to Stop Producing for USG	Explain
Paperwork/Requirements				
Slow Payment				
Small Production Lots				
Insufficient Profit Margin				
Infrequent Orders				
Intellectual Property Protection				
One-off orders				
Other	(specify here)			

Yes
No
Not Applicable

D. 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	Estimated Change Relative to IPC-6012 Class 3	Explain
Percentage direct change in fixed costs per slash sheet			
Percentage change in recurring costs for maintenance			
Percentage change in administrative cost of compliance			

Comments:	

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

Section 12b: Competitive Factors (continued)

A.

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?	
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	

Not at all
Somewhat
Moderately
Significantly
Not Applicable

B.

What level of overall industry consolidation do you expect to occur in the U.S. bare circuit board industry in the next five years?	
What two key factors do you see driving such a consolidation?	
Explain:	

None
Minimal
Moderate
Major

Improved production efficiency
Cost reduction
Excess production capacity
Not technologically competitive
Diminishing commercial orders
Shrinking USG orders
Increased foreign competition
Larger companies possess market advantages
Other

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

None
Minimal
Moderate
Major

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

Impact	-Yes/No-	Explain
Fewer U.S. materials manufacturers		
Greater dependence on non-U.S. materials		
Higher material costs		
Pricing advantage for larger board manufacturers		
Small companies less able to compete		
Reduced domestic board capability		
Shrinkage in manufacturing workforce		
Increased market share for non-U.S. companies		
Higher prices for bare board customers		
Other		
Other		

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?

	Action		Expected Impact on Organization	Explanation
A.	Increased funding of targeted bare circuit board manufacturing technology R&D			
	DOD requirement that electronic systems (not ITAR controlled) use circuit boards made in manufacturing facilities located in the U.S.			
	DOD adds circuit board laminate and related materials to the Defense National Stockpile			
	USG requirement that circuit boards produced for critical systems be manufactured with laminate and related materials made in the U.S.			
	DOD requirement for designated types of defense systems to use bare circuit boards manufactured in the U.S. by certified "trusted" suppliers			
	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)			
	Other	(specify here)		
	Other	(specify here)		

Benefit
No Change
Harm
Unclear Effect

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?	Internal Network (drop-down)
B.	Indicate who is responsible for your organization's internal IT networks:	
	Indicate who is responsible for your organization's external IT networks:	

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

C.	Commercially Sensitive Information (CSI) Type	-Yes/No-	Explanation
	Customer/client information		
	Financial information and records		
	Human resources information/employee data		
	Information subject to export control regulations (EAR and/or ITAR)		
	Intellectual property related information		
	Internal communications including negotiation points, merger and acquisition plans, and/or corporate strategy		
	Manufacturing and production line information		
	Patent and trademark information		
	Regulatory/compliance information		
	Research and development (R&D) related information		
	Supply chain and sourcing information		

Internal IT Department
Internal IT Department and U.S. external provider(s)
Internal IT Department and non-U.S. external provider(s)
Internal IT Department and U.S. and non-U.S. external provider(s)
Only U.S. external provider(s)
Only non-U.S. external provider(s)
U.S. and non-U.S. external provider(s)
Not Applicable

Comments:	

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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:	External Cloud Service Providers	
		External Data Storage Providers	
	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.

Event		Impact Level	Explanation
User idle time and lost productivity because of downtime or systems performance delays			
Disruption to normal operations because of system availability problems			
Damage or theft of IT assets and infrastructure			
Incurred cost of damage assessment and remediation			
Business interruption			
Exfiltration of CSI data			
Theft of personnel information			
Damage to software and/or source code			
Theft of software and/or source code			
Damage to company production capabilities or systems			
Destruction of information asset			
Reputation loss, market share, and brand damages			
Other	(specify here)		
Other	(specify here)		
Other	(specify here)		

None
Minimal
Moderate
Major

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. 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:	

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Section 14: Challenges and Outreach

A.

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.

Type of Issue	A Impact	B Rank Top 5	C Explanation
Aging equipment, facilities, or infrastructure			
Aging workforce			
Competition - domestic			
Competition - foreign			
Counterfeit parts			
Cyber security			
Environmental regulations/remediation - domestic			
Environmental regulations/remediation - foreign			
Export controls/ITAR & EAR			
Government acquisition process			
Government purchasing volatility			
Government regulatory burden			
Healthcare costs			
Health and safety regulations			
Intellectual property/patent infringement			
Labor availability/costs			
Material input availability			
Obsolescence			
Pension costs			
Proximity to customers			
Proximity to suppliers			
Qualifications/certifications			
Quality of material inputs			
R&D costs			
Reduction in commercial demand			
Reduction in USG demand			
Taxes			
Worker/skills retention			
Other (specify here)			

Current
Future
Both
No

1
2
3
4
5

B.

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.

Continuous Improvement/ Lean Manufacturing		Market Expansion/Business Growth	
Cyber Security		Product Design	
Design for Assembly		Prototyping	
Design for Manufacturability		Quality Management and Control	
Energy and Environmentally Conscious Manufacturing		Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts	
Export Assistance		Supply Chain Optimization	
Export Licensing (ITAR/EAR)		Technology Acceleration	
Government Procurement Guidelines		Vendor/Material Sourcing	
Other (specify here)		Other (specify here)	

Comments:

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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.

Facility Name	
Organization Name	
Organization's Internet Address	
Name of Authorizing Official	
Title of Authorizing Official	
E-mail Address	
Phone Number and Extension	
Date Certified	

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?	

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OFFICE OF TECHNOLOGY EVALUATION (OTE)
Publication List
November 2018

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	Date
U.S. Air Force Industrial Supply Chain Sustainment Assessment	2020
U.S. Software Integration in Infrastructure Network Systems Assessment	2019
The Effect of Imports of Uranium on the National Security	2019
U.S. Integrated Circuit Design and Manufacturing Industry Assessment	2019

Recent Assessments	Date
U.S. Air Force C-17 Aircraft Supply Chain Impact Assessment	2018
U.S. Rocket Propulsion Industrial Base Assessment	2018
The Effect of Imports of Steel on the National Security	Jan. 2018
The Effect of Imports of Aluminum on the National Security	Jan. 2018
U.S. Footwear Industrial Base Assessment	Summer 2017
U.S. Textile and Apparel Industrial Base Assessment	Summer 2017
U.S. Bare Printed Circuit Board Industry Assessment	2017
U.S. Strategic Material Supply Chain Assessment: Select Rare Earth Elements	2016
U.S. Strategic Material Supply Chain Assessment: Titanium	Spring 2016
U.S. Strategic Material Supply Chain Assessment: Carbon Fiber Composites	Fall 2015
Defense Industrial Base Assessment of the U.S. Underwater Acoustics Transducer Industry	Spring 2015
Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages (Update)	Feb. 2015
U.S. Space Industrial Base "Deep Dive" Assessment: Small Businesses	Dec. 2014
U.S. Space Industrial Base "Deep Dive" Assessment: Workforce Issues	Sept. 2014
U.S. Space Industrial Base "Deep Dive" Assessment: Export Controls	Feb. 2014
Industrial Base Assessment of Consumers of U.S. Electro-Optical (EO) Satellite Imagery	Aug. 2013
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: 4th Review	July 2013
Critical Technology Assessment: Night Vision Focal Plane Arrays, Sensors, and Cameras	Oct. 2012
National Aeronautics and Space Administration (NASA) Industrial Base – Post-Space Shuttle	June 2012
Defense Industrial Base Assessment of the Telecommunications Industry Infrastructure	Apr. 2012
Reliance on Foreign Sourcing in the Healthcare and Public Health (HPH) Sector	Dec. 2011
Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages	Aug. 2010
Critical Technology Assessment: Impact of U.S. Export Controls on Green Technology Items	Aug. 2010
Technology Assessment of Fine Grain, High-Density Graphite	Apr. 2010
Defense Industrial Base Assessment of Counterfeit Electronics	Jan. 2010
Technology Assessment of 5-Axis Machine Tools	July 2009

For further information about OTE's programs or for copies of assessments please visit http://www.bis.doc.gov/dib
Please visit www.bis.doc.gov/232 for Section 232 Investigations and www.bis.doc.gov/criticaltech for Technology Assessments.

Archived Assessments	Date
Defense Industrial Base Assessment of U.S. Integrated Circuit Design and Fabrication Capability	Mar. 2009
Defense Industrial Base Assessment of the U.S. Space Industry	Aug. 2007
Technology Assessment of Certain Aromatic Polyimides	July 2007
Defense Industrial Base Assessment of U.S. Imaging and Sensors Industry	Oct. 2006
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Third Review	Aug. 2006
Economic Impact Assessment of the Air Force C-17 Program	Dec. 2005
National Security Assessment of the Munitions Power Sources Industry	Dec. 2005
National Security Assessment of the Air Delivery (Parachute) Industry	May 2004
Industry Attitudes on Collaborating with DoD in R&D – Air Force	Jan. 2004
Industrial Base/Economic Impact Assessment of Army Theater Support Vessel Procurement	Dec. 2003
A Survey of the Use of Biotechnology in U.S. Industry	Oct. 2003
Industrial Base Assessment of U.S. Textile and Apparel Industries	Sept. 2003
Technology Assessment of U.S. Assistive Technology Industry	Feb. 2003
Heavy Manufacturing Industries: Economic Impact and Productivity of Welding – Navy	June 2002
The Effect of Imports of Iron Ore and Semi-Finished Steel on the National Security	Oct. 2001
National Security Assessment of the U.S. High-Performance Explosives & Components Sector	June 2001
Statistical Handbook of the Ball and Roller Bearing Industry (Update)	June 2001
National Security Assessment of the U.S. Shipbuilding and Repair Industry	May 2001
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Update	Dec. 2000
The Effect on the National Security of Imports of Crude Oil and Refined Petroleum Products	Nov. 1999
U.S. Commercial Technology Transfers to The People's Republic of China	Jan. 1999
Critical Technology Assessment of Optoelectronics	Oct. 1998
National Security Assessment of the Emergency Aircraft Ejection Seat Sector	Nov. 1997
Critical Technology Assessment of the U.S. Semiconductor Materials Industry	Apr. 1997

Archived Assessments	Date
National Security Assessment of the Cartridge and Propellant Actuated Device Industry	Oct. 1995
International Market for Computer Software with Encryption – NSA	1995
The Effect of Imports of Crude Oil and Petroleum Products on the National Security	Dec. 1994
Critical Technology Assessment of U.S. Artificial Intelligence	Aug. 1994
Critical Technology Assessment of U.S. Superconductivity	Apr. 1994
Critical Technology Assessment of U.S. Optoelectronics	Feb. 1994
Critical Technology Assessment of U.S. Advanced Ceramics	Dec. 1993
Critical Technology Assessment of U.S. Advanced Composites	Dec. 1993
The Effect of Imports of Ceramic Semiconductor Packages on the National Security	Aug. 1993
National Security Assessment of the U.S. Beryllium Industry	July 1993
National Security Assessment of the Antifriction Bearings Industry	Feb. 1993
National Security Assessment of the U.S. Forging Industry	Dec. 1992
The Effect of Imports of Gears & Gearing Products on the National Security	July 1992
National Security Assessment of the Domestic and Foreign Subcontractor Base - 3 U.S. Navy Systems	Mar. 1992
National Security Assessment of the U.S. Semiconductor Wafer Processing Equipment Industry	Apr. 1991
National Security Assessment of the U.S. Robotics Industry	Mar. 1991
National Security Assessment of the U.S. Gear Industry	Jan. 1991
The Effect of Imports of Uranium on the National Security	Sept. 1989
The Effect of Imports of Crude Oil and Refined Petroleum on the National Security	Jan. 1989
The Effect of Imports of Plastic Injection Molding Machines on the National Security	Jan. 1989
The Effect of Imports of Anti-Friction Bearings on the National Security	July 1988
Investment Castings: A National Security Assessment	Dec. 1987
Joint Logistics Commanders/DOC Precision Optics Study	June 1987
An Economic Assessment of the U.S. Industrial Fastener Industry	Mar. 1987
Joint Logistics Commanders/DOC Bearing Study	June 1986

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