



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

U.S. BARE PRINTED CIRCUIT BOARD INDUSTRY SURVEY RESULTS

IPC APEX Expo – Government Relations
February 27, 2018

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



BIS Industry Surveys & Assessments

Background

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

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

- Enable industry and government agencies to:
 - Share data and collaborate in order to ensure a healthy and competitive industrial base
 - Monitor trends and benchmark industry performance
 - Raise awareness of diminishing manufacturing and technological capabilities



Bare Printed Circuit Board Assessment Sponsor



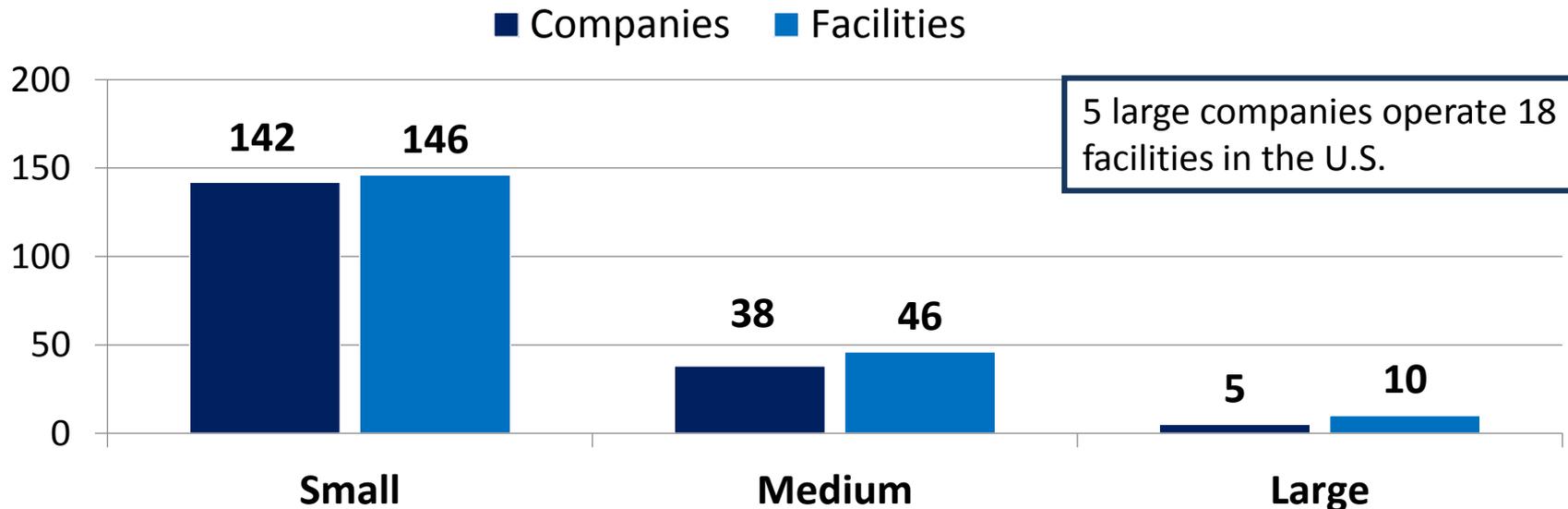
- Bureau of Industry and Security, in coordination with the U.S. Department of the Navy, Naval Surface Warfare Center, Crane Division (NSWC Crane) conducted an assessment of the U.S. Bare Printed Circuit Board (PCB) industrial base.



Bare PCB Respondent Profile

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

Number of Companies/Facilities by Bare PCB Sales

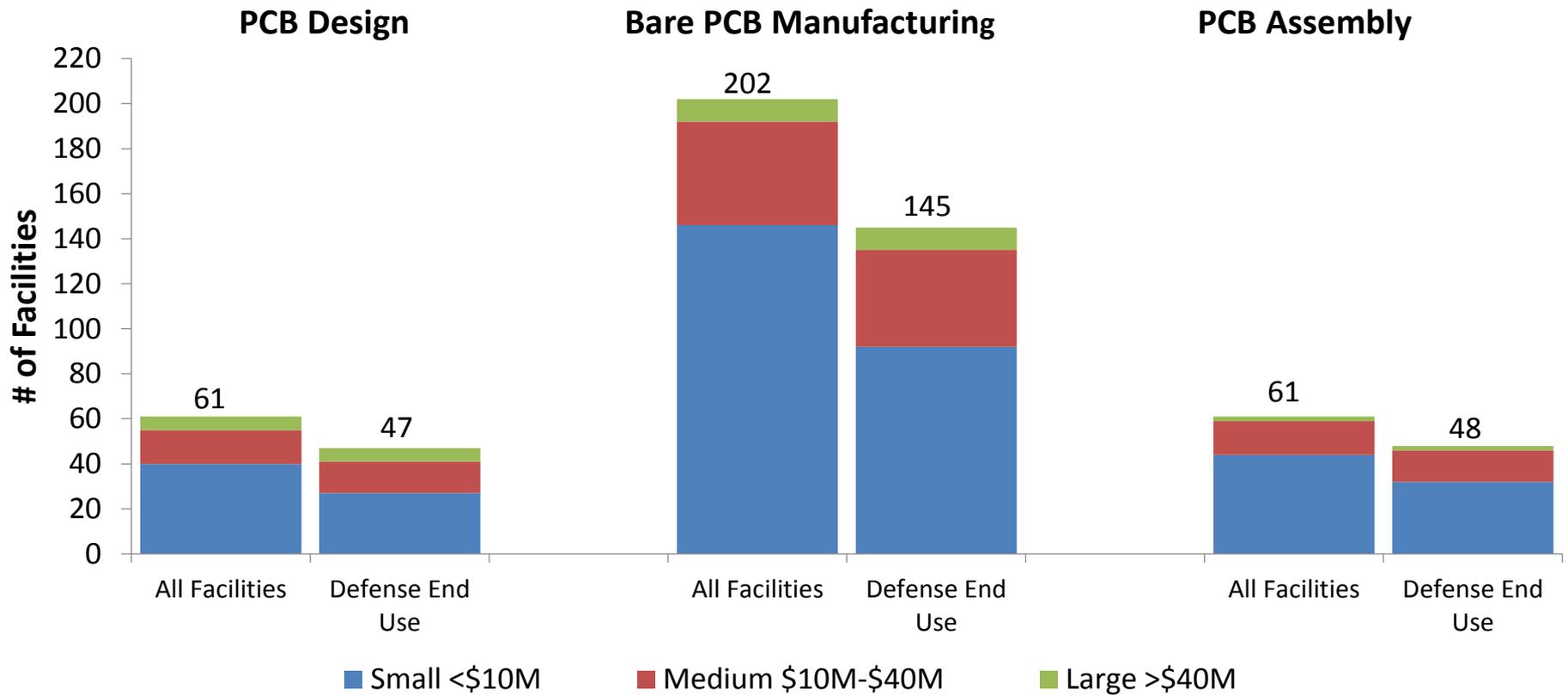


Small: < \$10M in sales Medium: \$10M-\$40M in sales Large: > \$40M in sales



U.S. Bare PCB Facility Capabilities

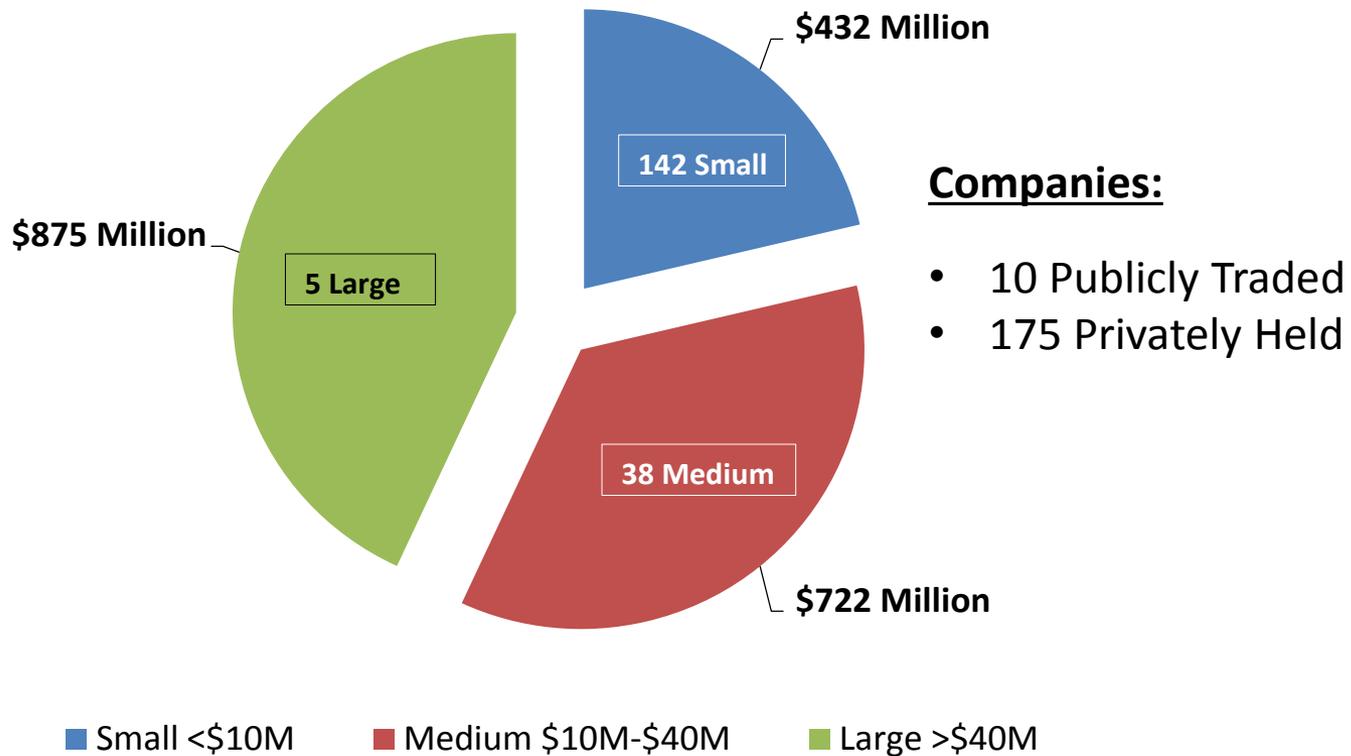
Manufacturing Services – All U.S. Bare PCB Facilities - 2015





Bare PCB Sales 2015 – By Company Size

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

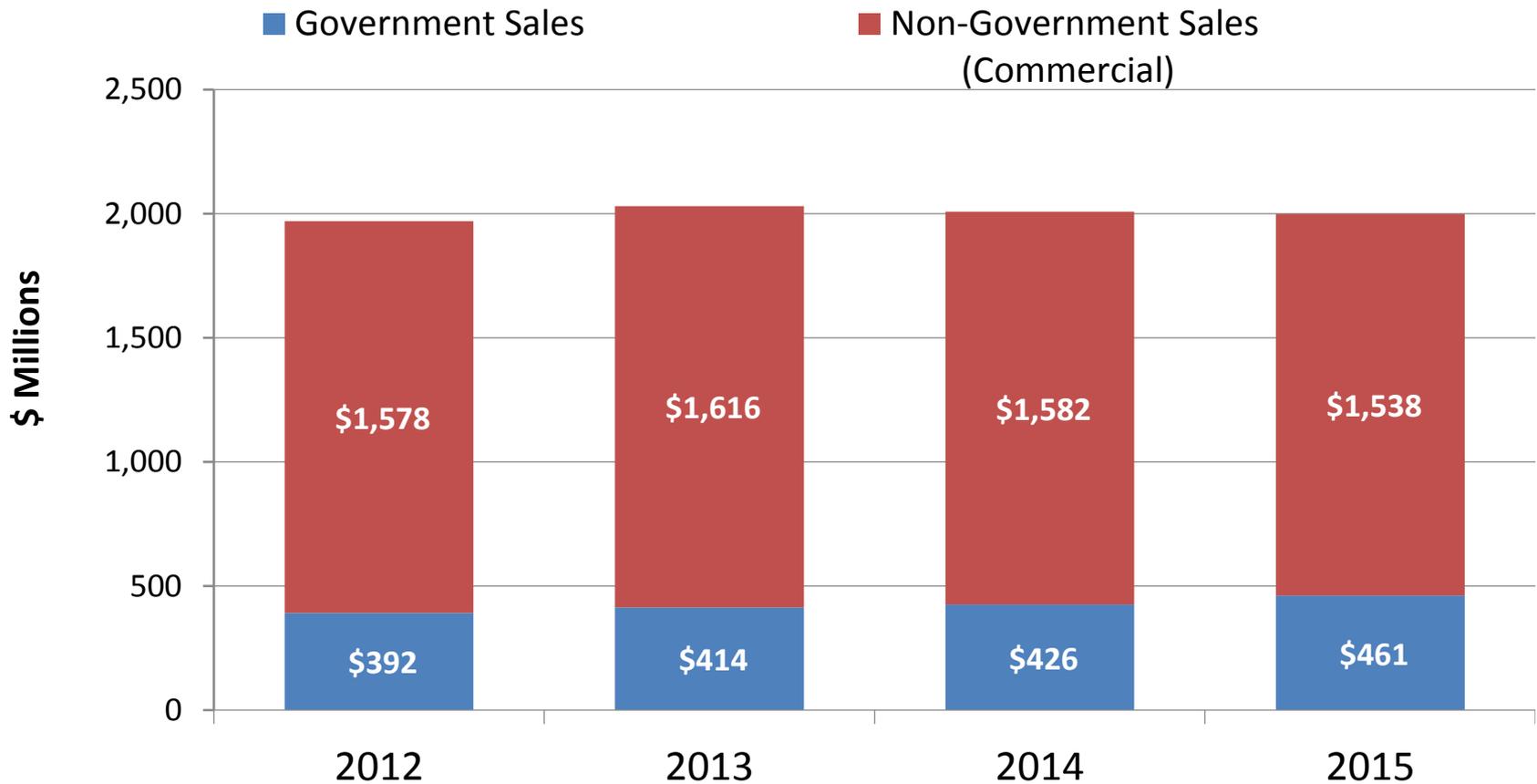




Bare PCB Sales 2012-2015

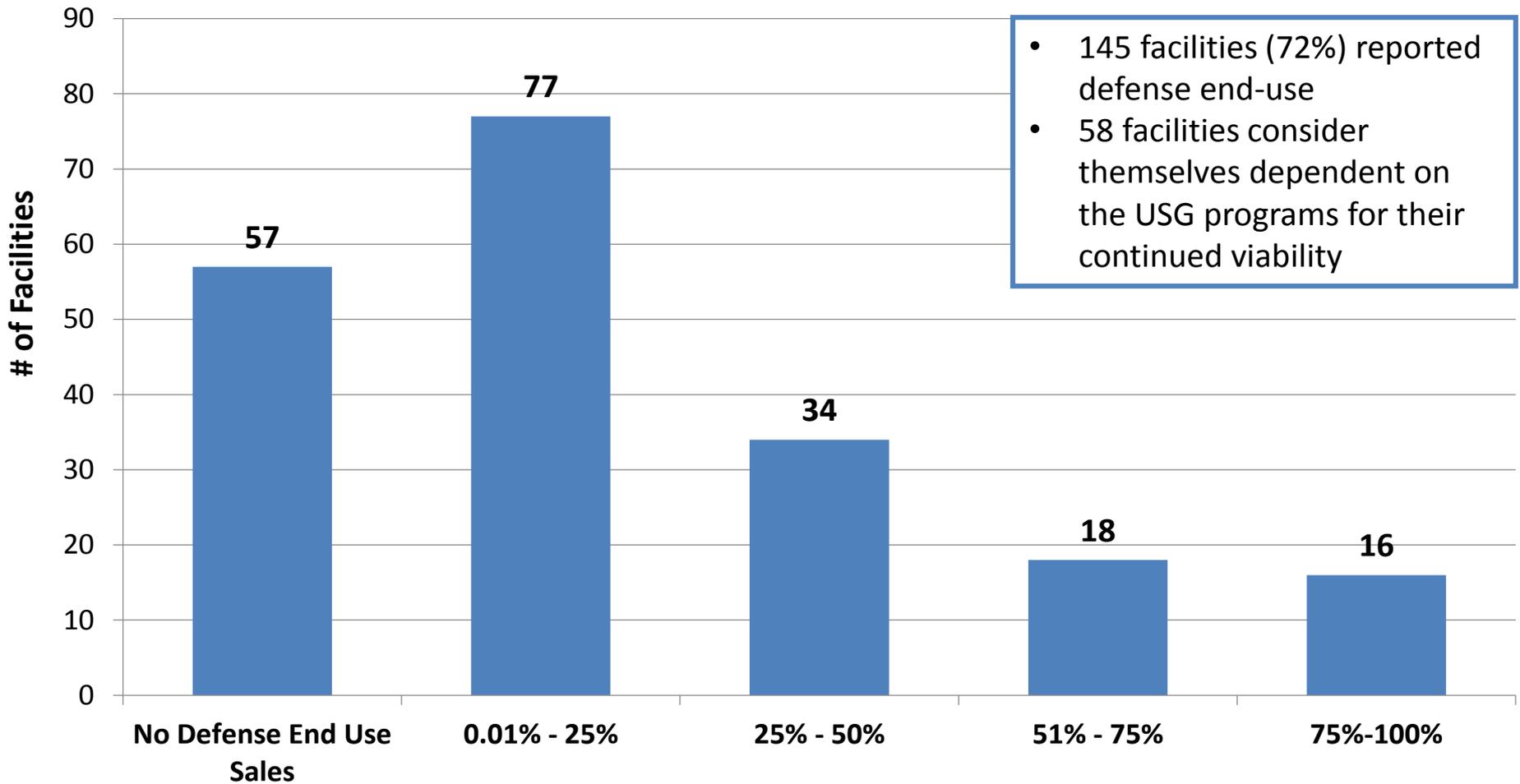
- Government vs. Non-Government Sales

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





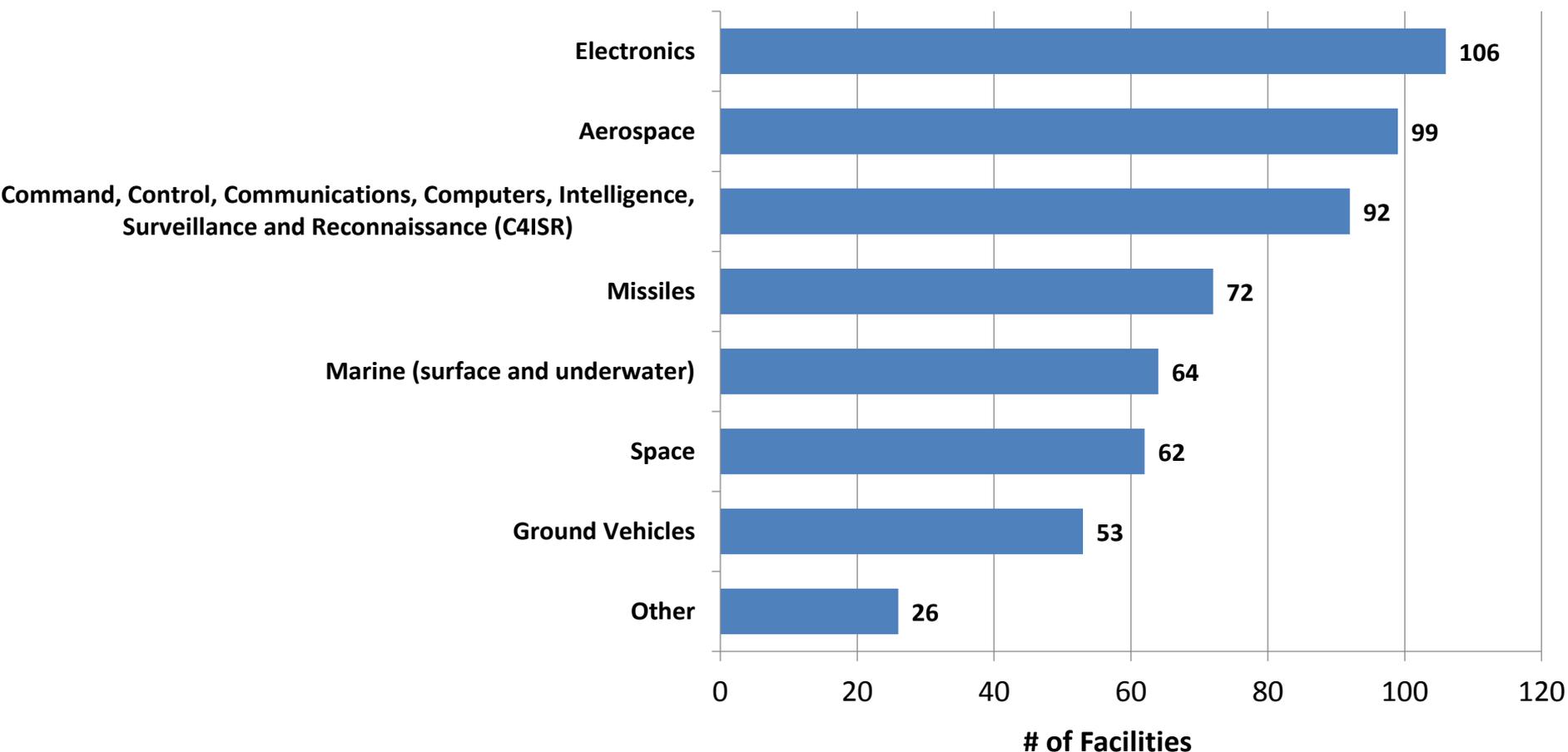
Percent of Bare PCB Sales with Defense End Use – 2015





Defense End Use Market Segments

U.S. Bare PCB Facilities – Defense Segments Participation



Q1c,A

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

145 respondents

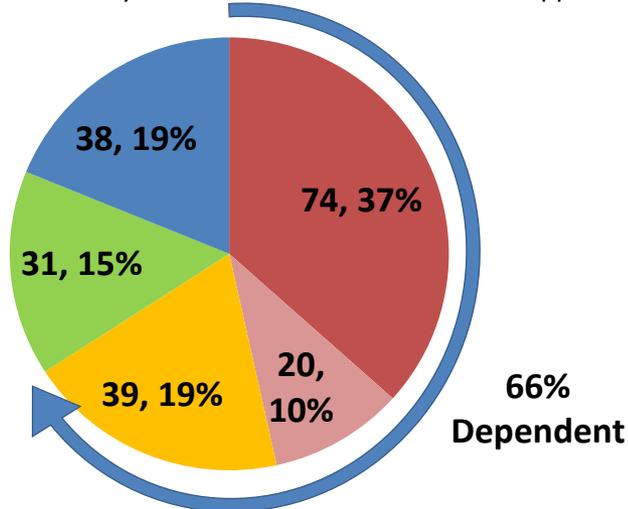


Competitive Factors – Reliance on USG Business

- 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.

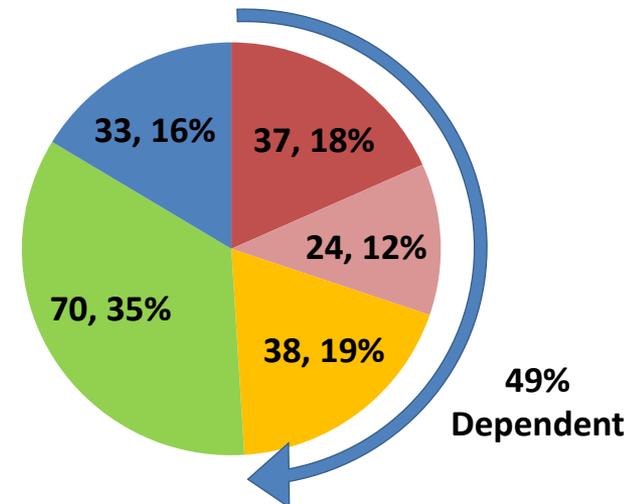
To what extent is this facility's continued ability to manufacture bare circuit boards for USG Customers dependent on the viability of your commercial circuit board business?

■ Significantly ■ Moderately ■ Somewhat ■ Not at all ■ Not Applicable



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

■ Significantly ■ Moderately ■ Somewhat ■ Not at all ■ Not Applicable



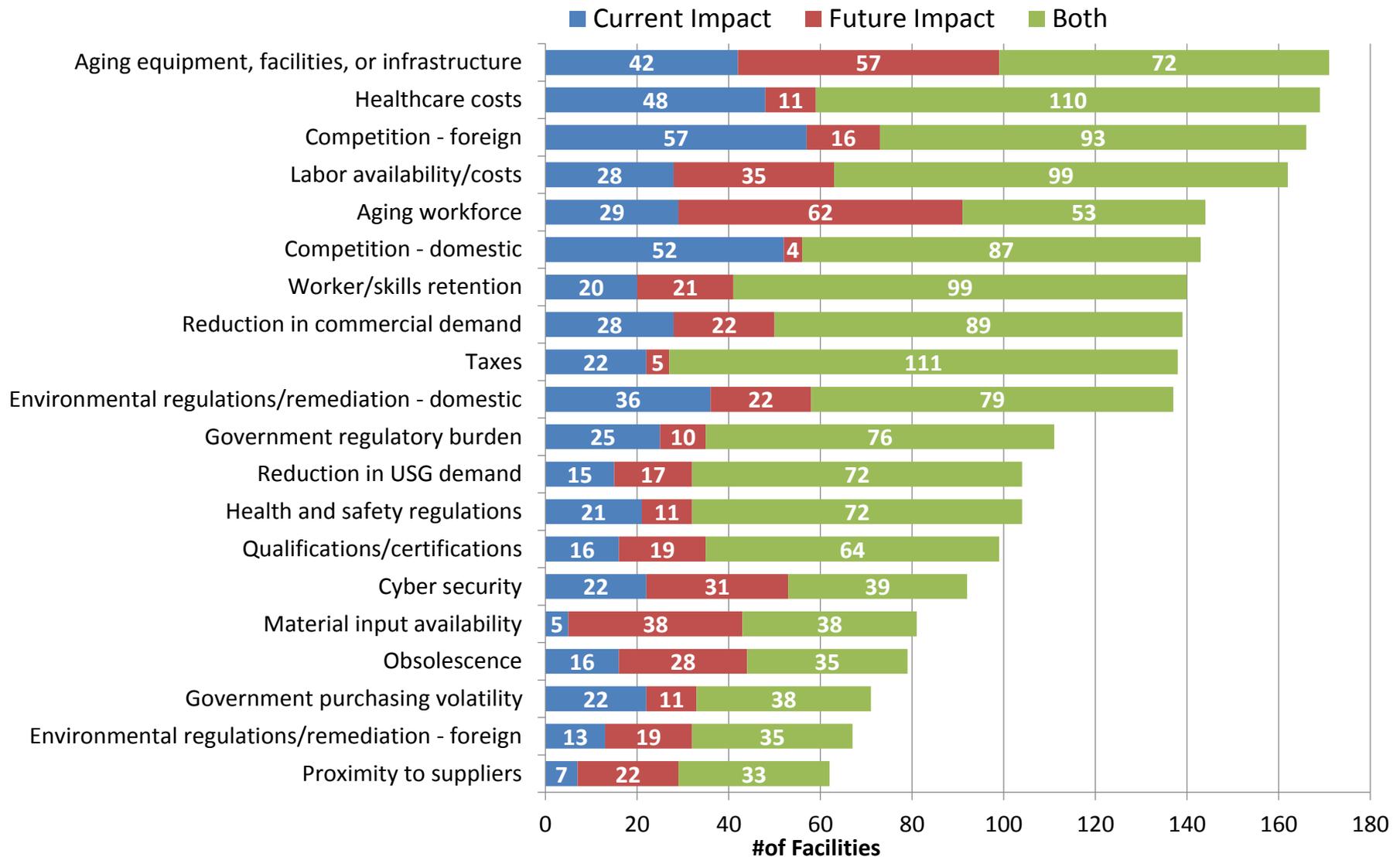
Q12b,A

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

202 respondents

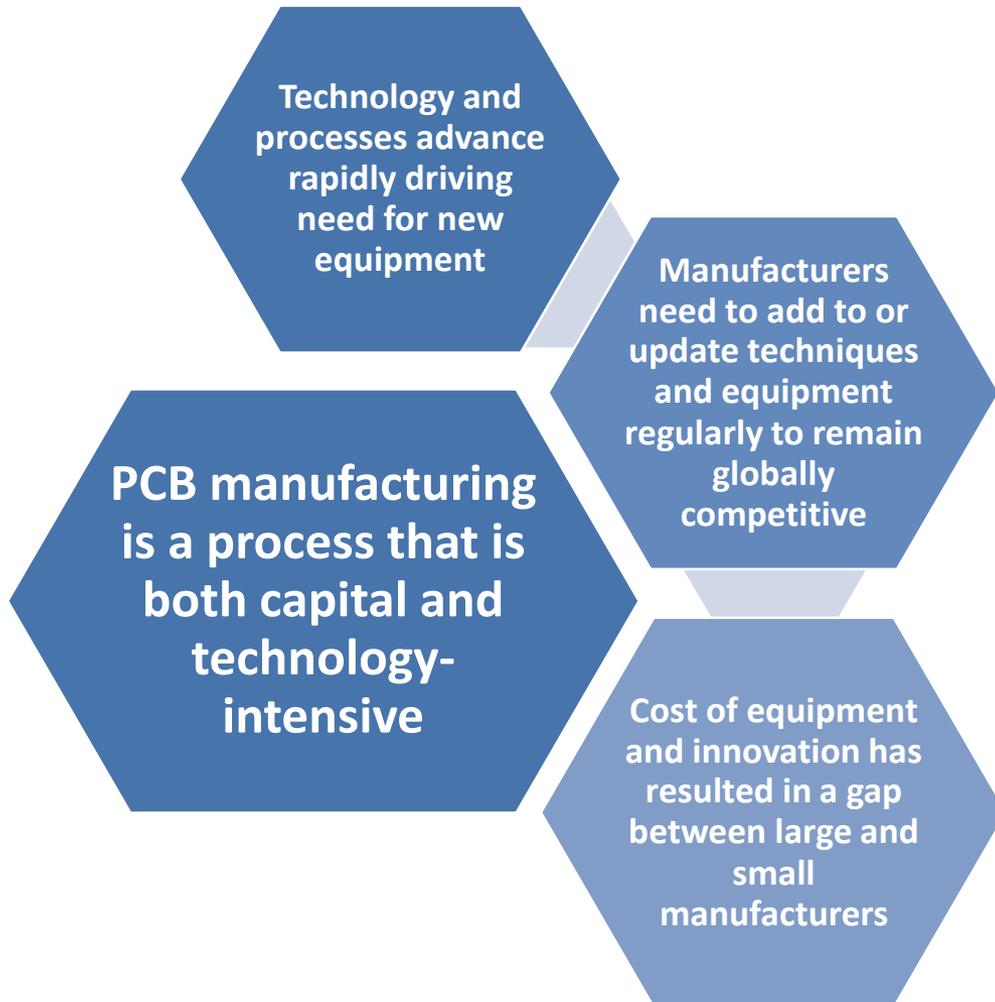


Current and Future Issues of Concern to Industry





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%

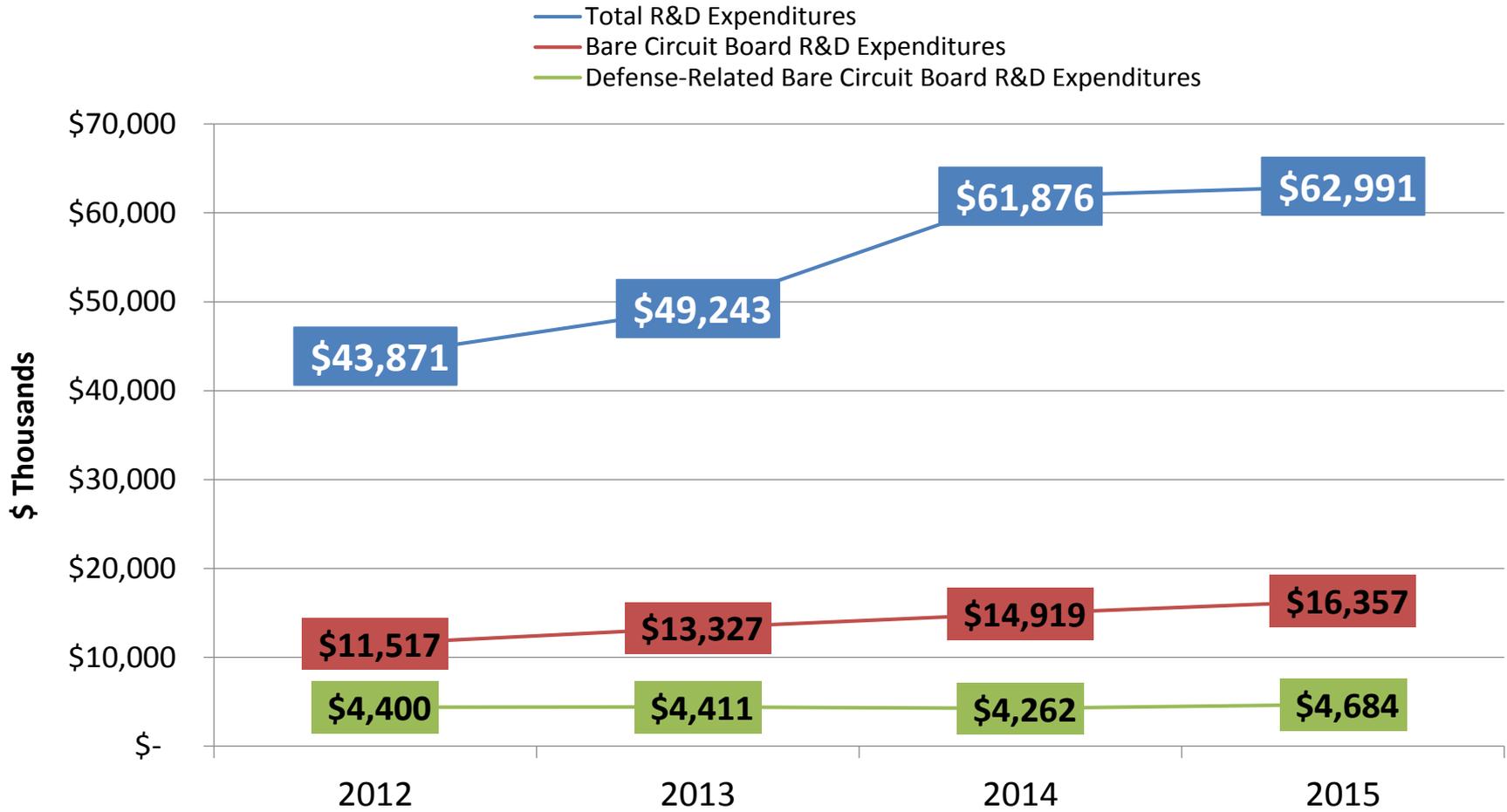
Only 38 out of 185 companies reported conducting R&D:

- Large - 5 (80%)
- Medium - 15 (39%)
- Small - 20 (13%)



R&D – Bare PCB/Defense-Related Expenditures

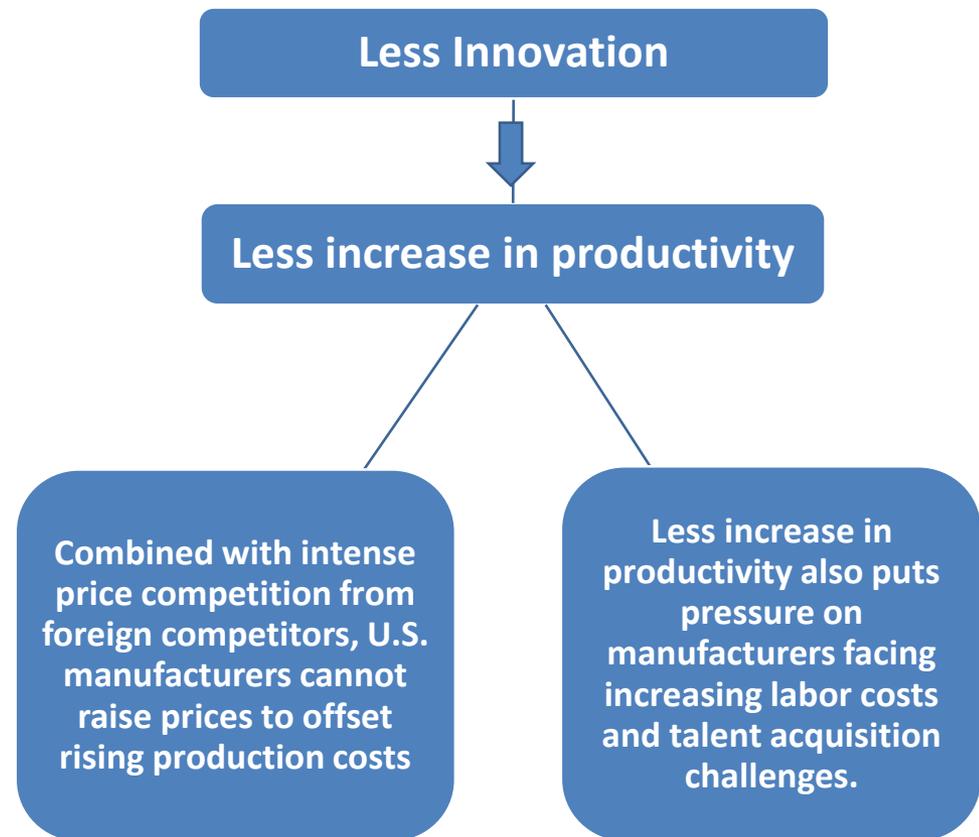
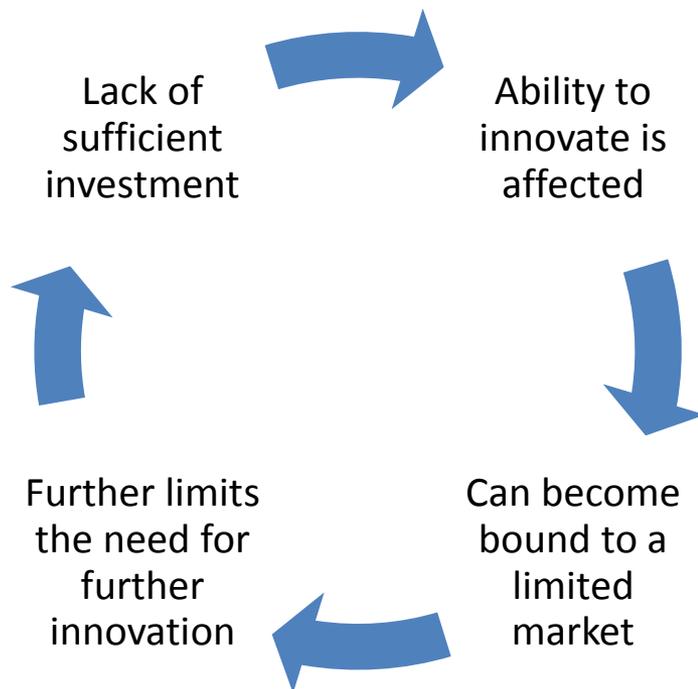
U.S. Bare PCB Facilities R&D Expenditures 2012-2015



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

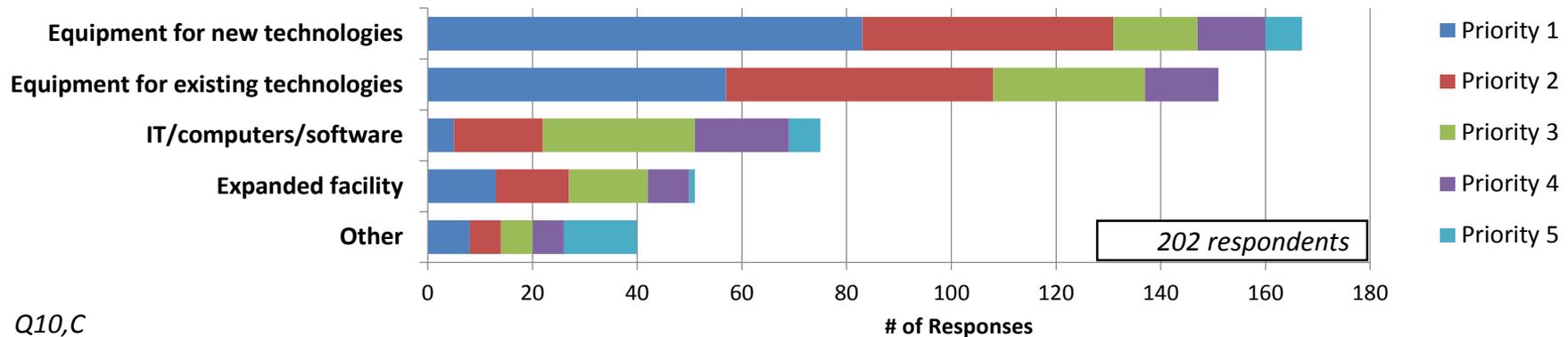
Why this is a problem for small-scale PCB enterprises:





CAPEX: Top Priorities for U.S. PCB Manufacturers

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



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

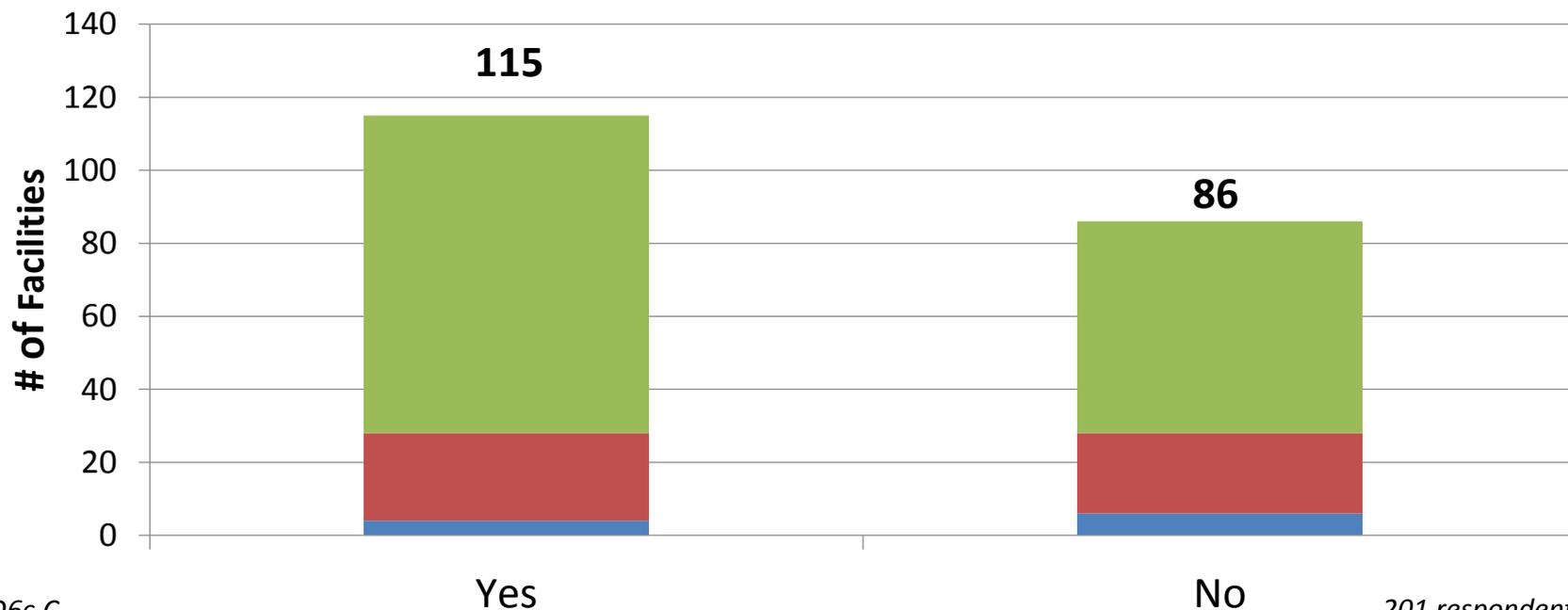


Manufacturing Limitations Due To Equipment

U.S. PCB manufacturing facilities – over half reported equipment-related production limitations

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

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



Q6c,C

201 respondents

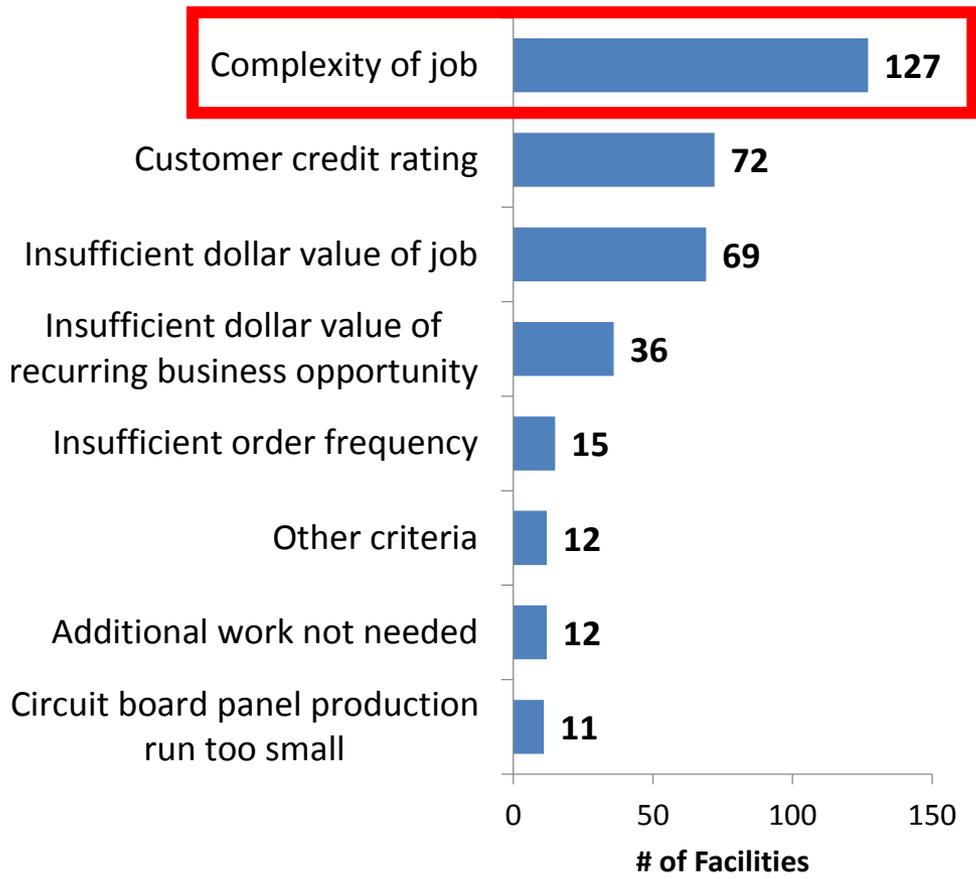
Source: U.S. Department of Commerce, Bureau of Industry and Security
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Rejected Customer Business Opportunities

Factors for Rejecting Business Opportunities

EXPLANATIONS:



Complexity of job:

- “Do not possess 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.”

Other comments:

- “Lacking credentials (e.g., MIL-PRF-31032)”
- “We are not a military approved facility.”
- “Our minimum lot charge is higher than commercial competition due to MIL documentation.”

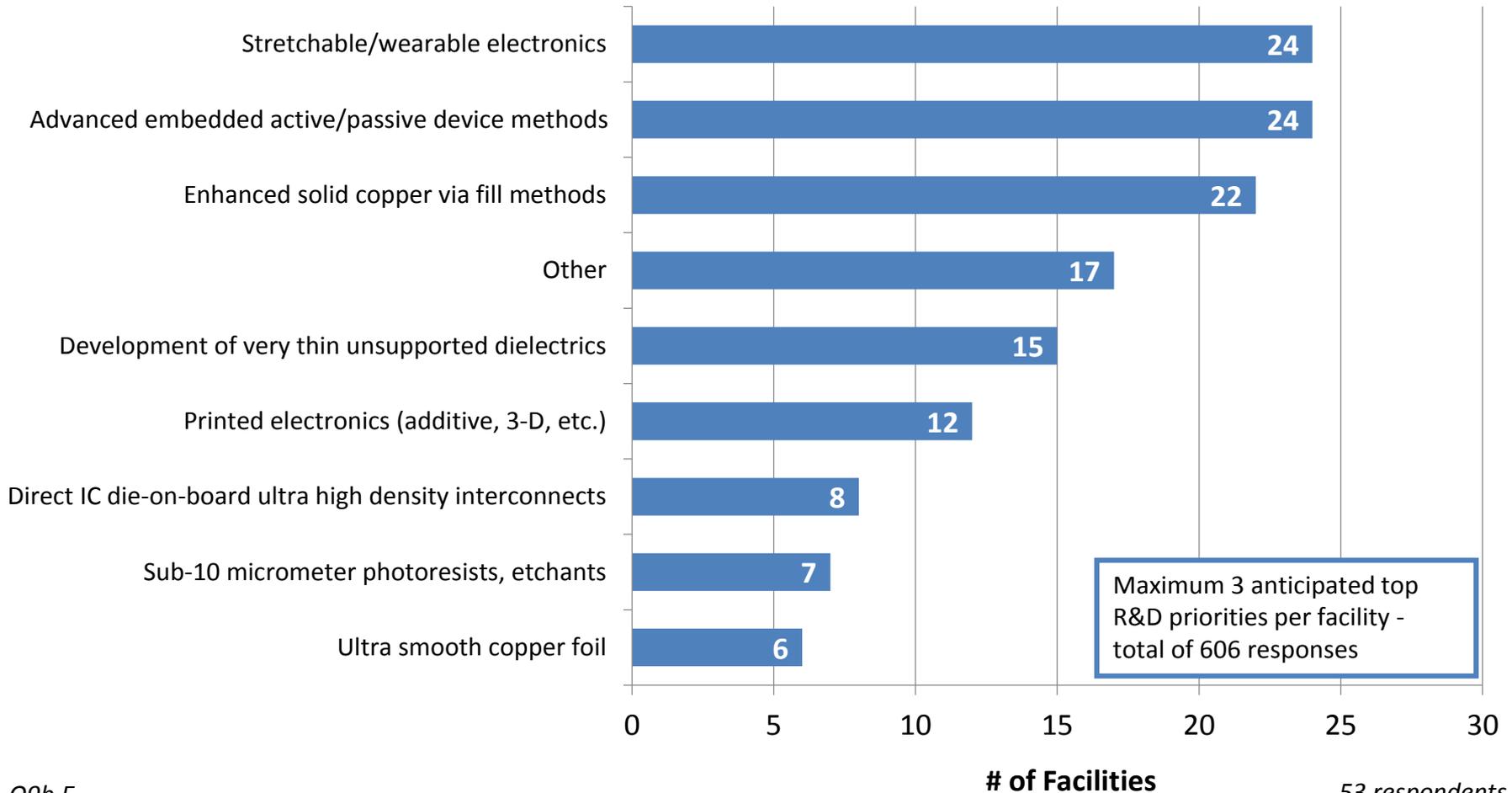
Q3a,B

202 respondents



R&D – Technology Priorities for DoD

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



Q9b,E

53 respondents



Need for R&D and Capital Investment (CAPEX)

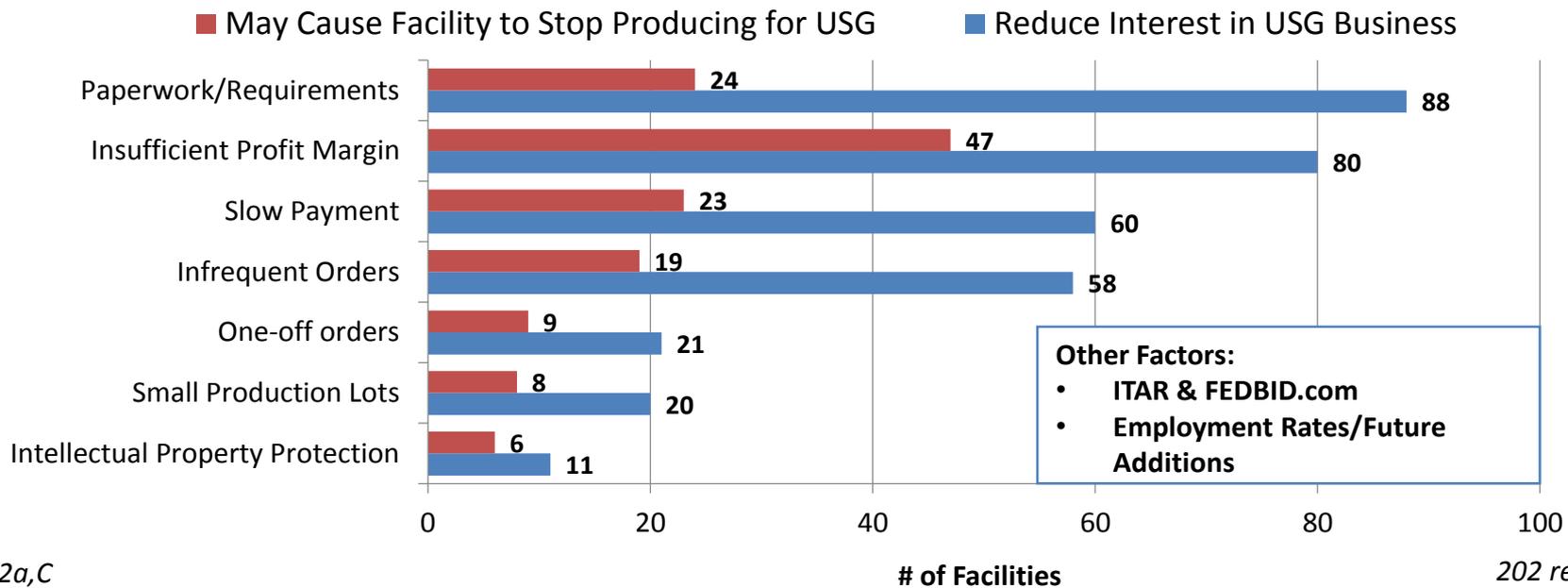
- “Innovation is important to meeting both legacy and future DoD needs.”
- R&D for PCBs has shifted offshore (partly due to foreign government R&D support and growth in Asian PCB manufacturing)
- U.S. PCB manufacturers, facing lower margins and lower sales volumes, are becoming limited in their investments in R&D, technology, and innovation.
 - 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 imperative 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.
- **RECOMMENDATIONS:** U.S. PCB Industry partnership and collaboration efforts (consortium) to conduct R&D?
 - Possible partners - NIST, DARPA, 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.



Factors Affecting Facility Interest in USG Business

- 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 U.S. Government business.



Q12a,C



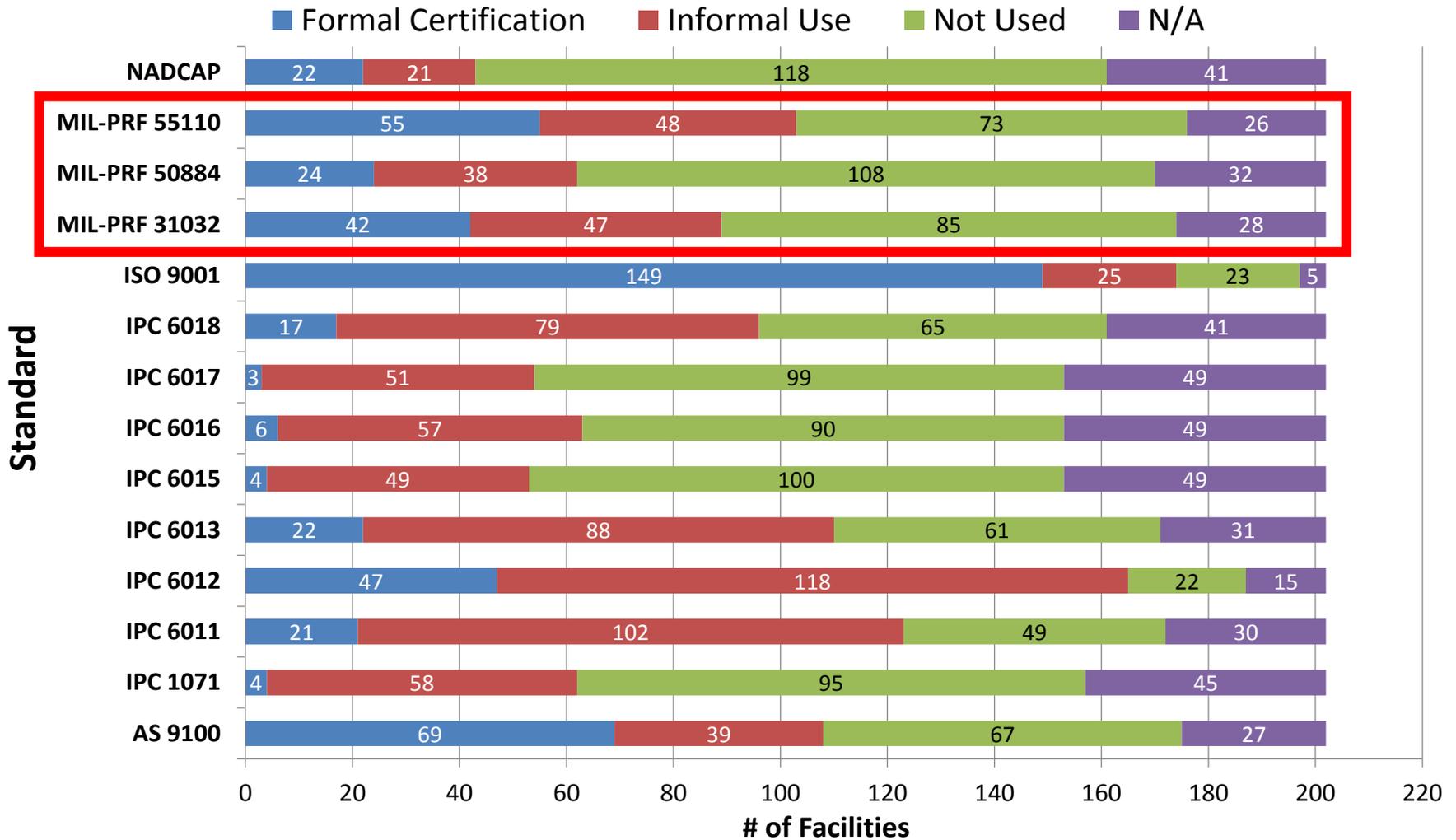
Working with DoD – MIL Certification

- 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.”
- **RECOMMENDATION:**
 - Increase/create funding program to help small U.S. PCB manufacturers achieve formal certifications. (ex: MIL-PRF).



Facility Manufacturing Capabilities - Standards

Standards Employed by U.S. Bare PCB Facilities



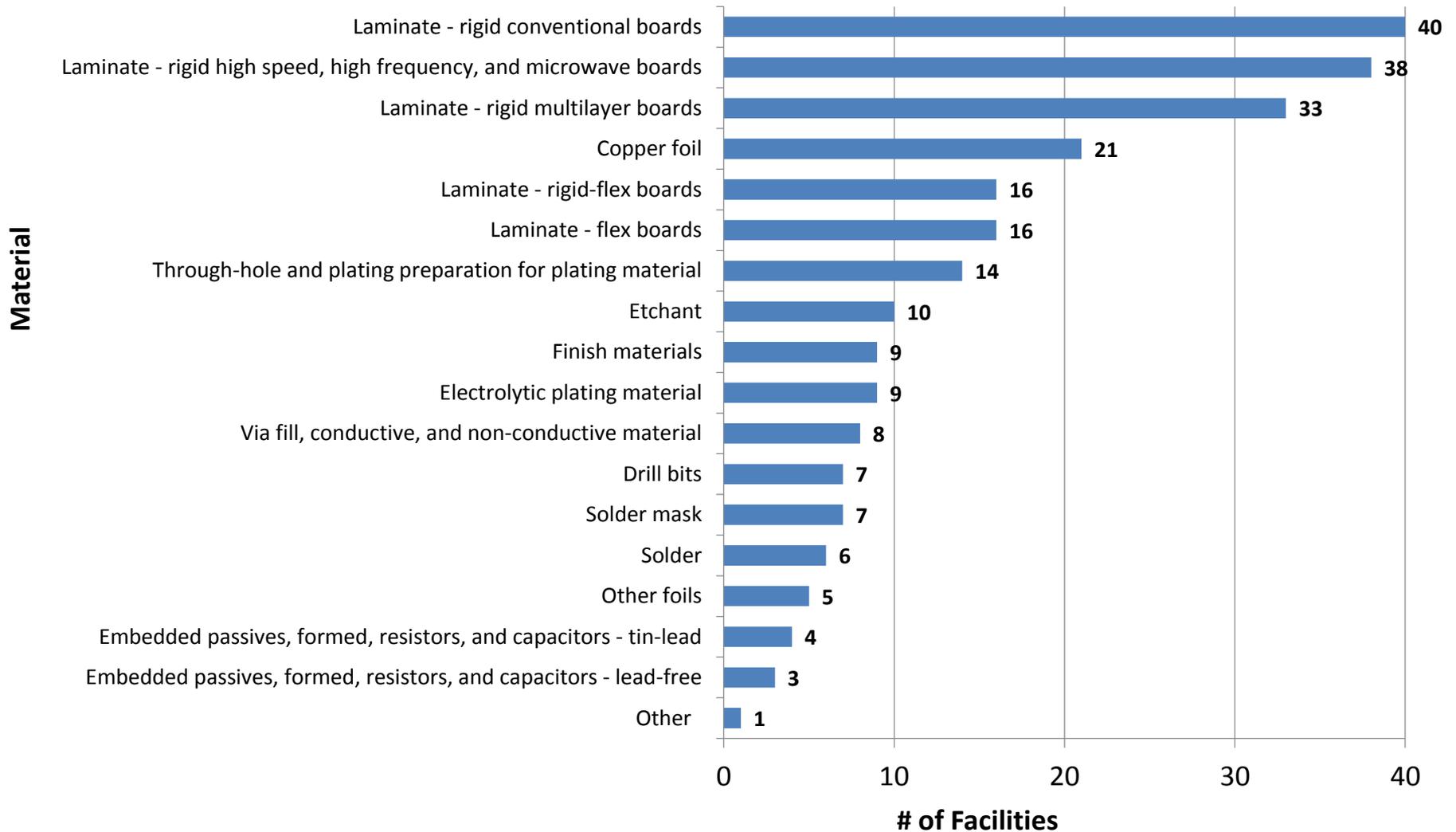


Supply Chain

- 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 them following PCB production overseas.
 - Also, many in the sector 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.**



Supply Chain: Operators Encountering Disruptions Since 2012



Q6a,A

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

202 respondents

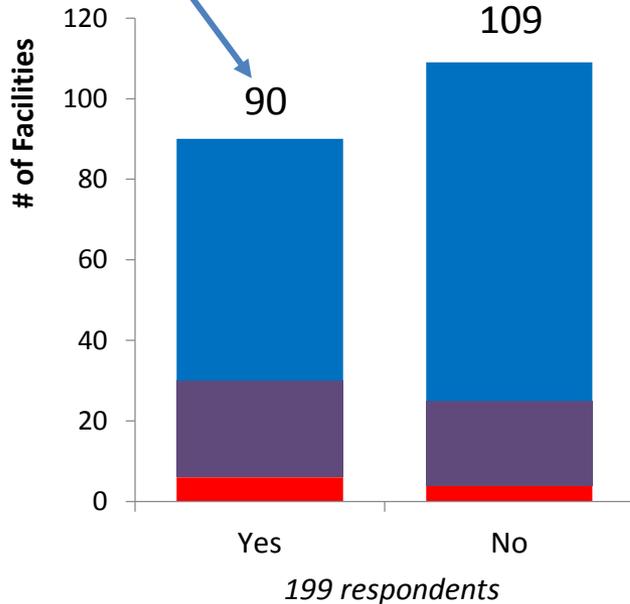


Supply Chain Disruptions - Example

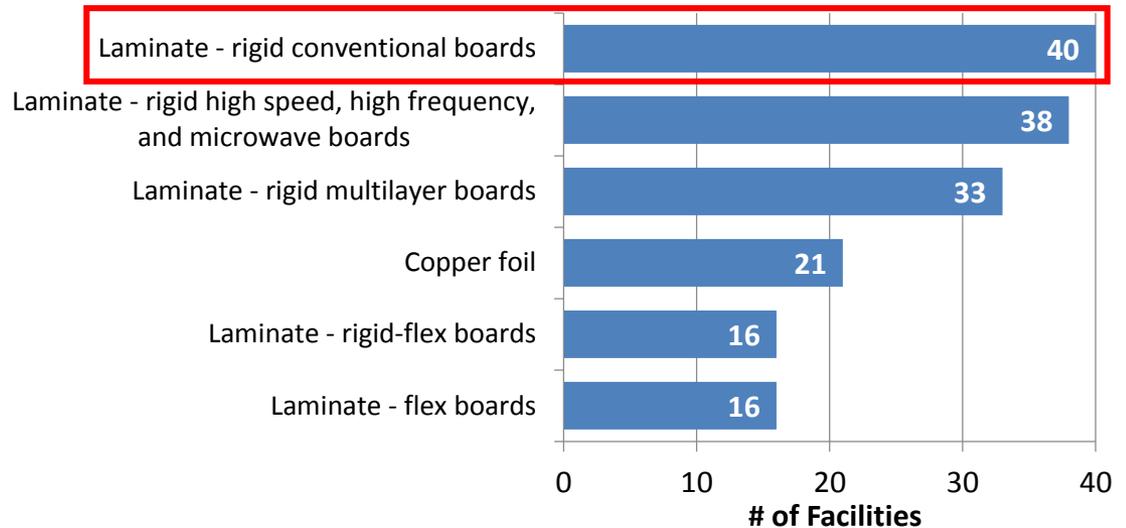
Does a reduction in U.S.-based companies that manufacture laminates and other circuit board-related materials create supply problems for this facility?

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

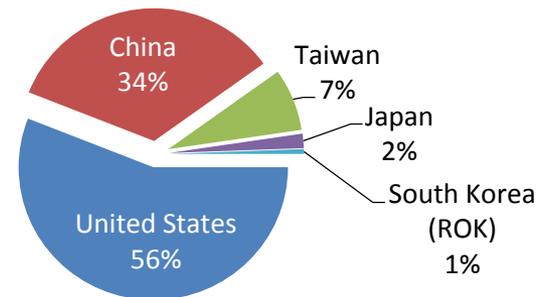
77% reported defense-related sales



Top Experienced Material Supply Chain Disruptions Since 2012



Suppliers Listed – Countries: Laminate – rigid conventional board





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 are needed. Other USG agencies as well as industry needs to participate in this effort.
- **Recommendations/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.



Employment - Challenges

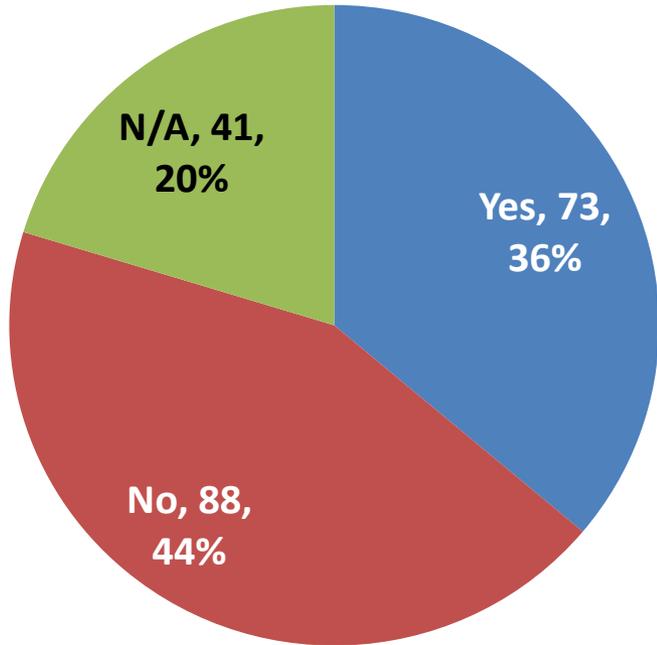
- Thirty-six percent of BIS survey respondents reported current difficulties hiring and retaining employees.
- Top two key future workforce-related issues anticipated (2016-2020).
 - Finding experienced workers – 65% of respondents
 - Finding qualified workers – 52% of respondents
- Aging workforce and 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”



Industry Hiring and Retention Issues

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

Yes No N/A



202 respondents

Q11a, B/C

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

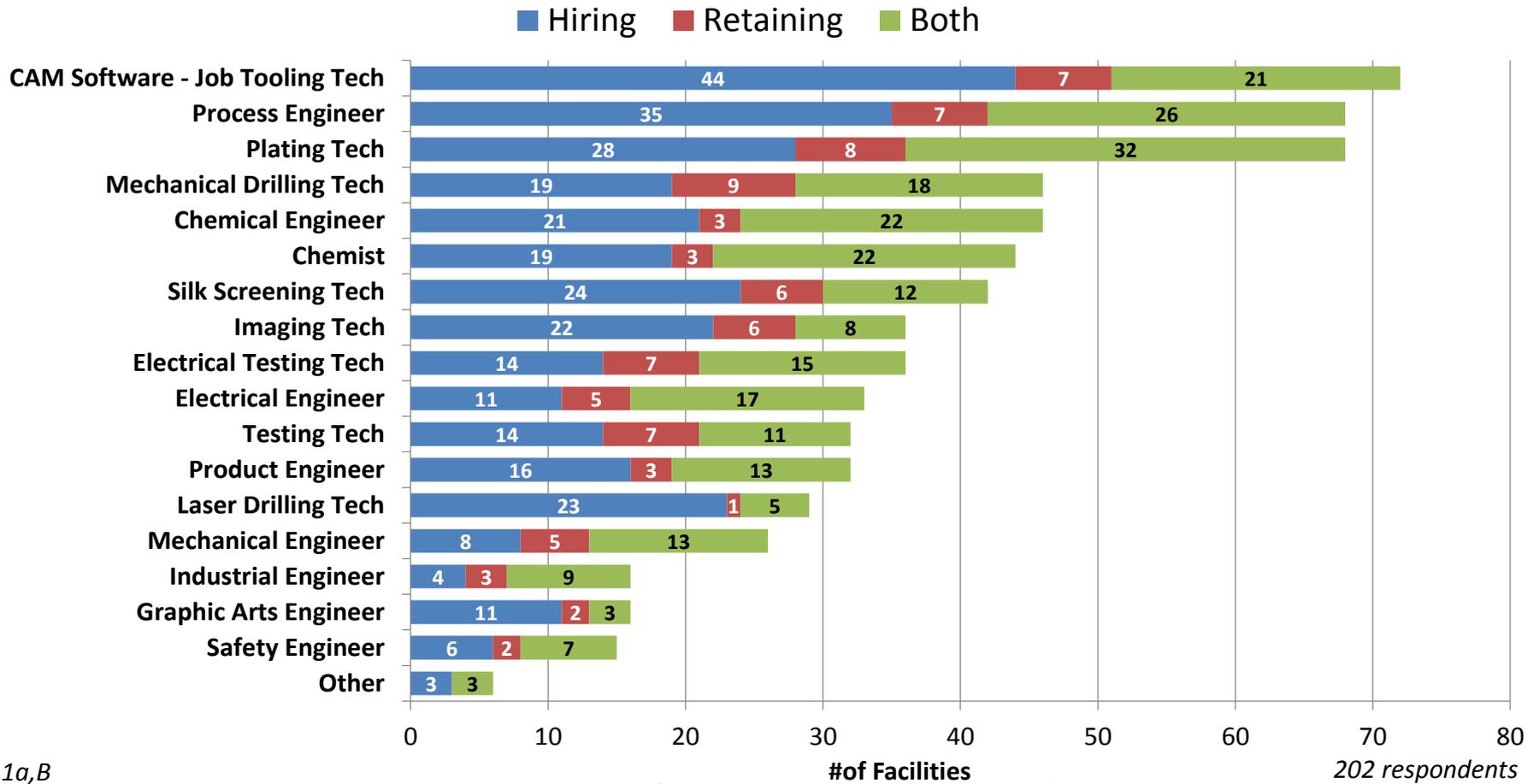


202 respondents



U.S. Bare PCB Workforce - Hiring/Retention Difficulty by Job Category

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



Q11a,B

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



Employment - Challenges

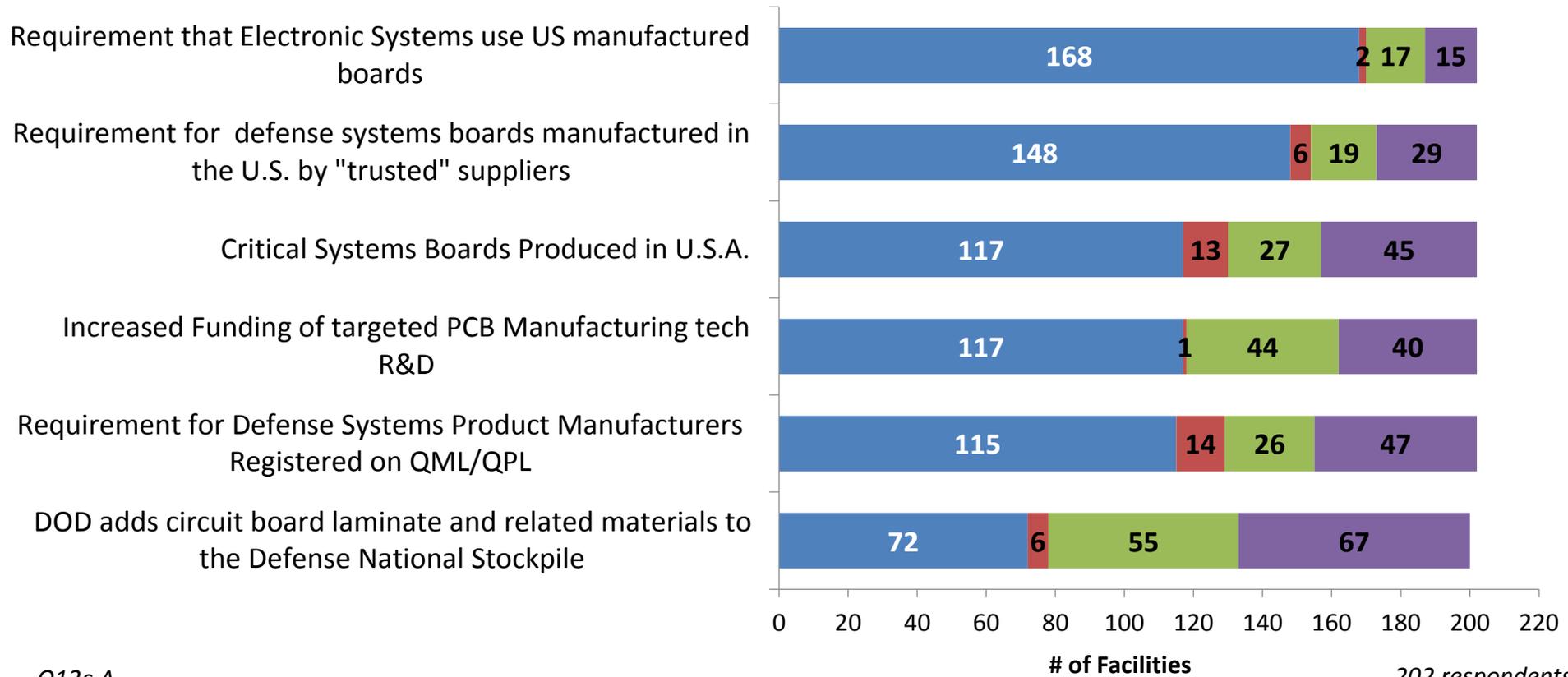
- The industry's ability to recruit and hire a qualified sustainable workforce seems to be limited by two key factors.
 - Shortage of prospective employees who have the essential skills needed to be successful in a PCB manufacturing capacity.
 - A general shortage of young people interested in manufacturing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



Views on Potential USG Bare PCB Actions

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

■ Benefit ■ Harm ■ No Change ■ Unclear



202 respondents

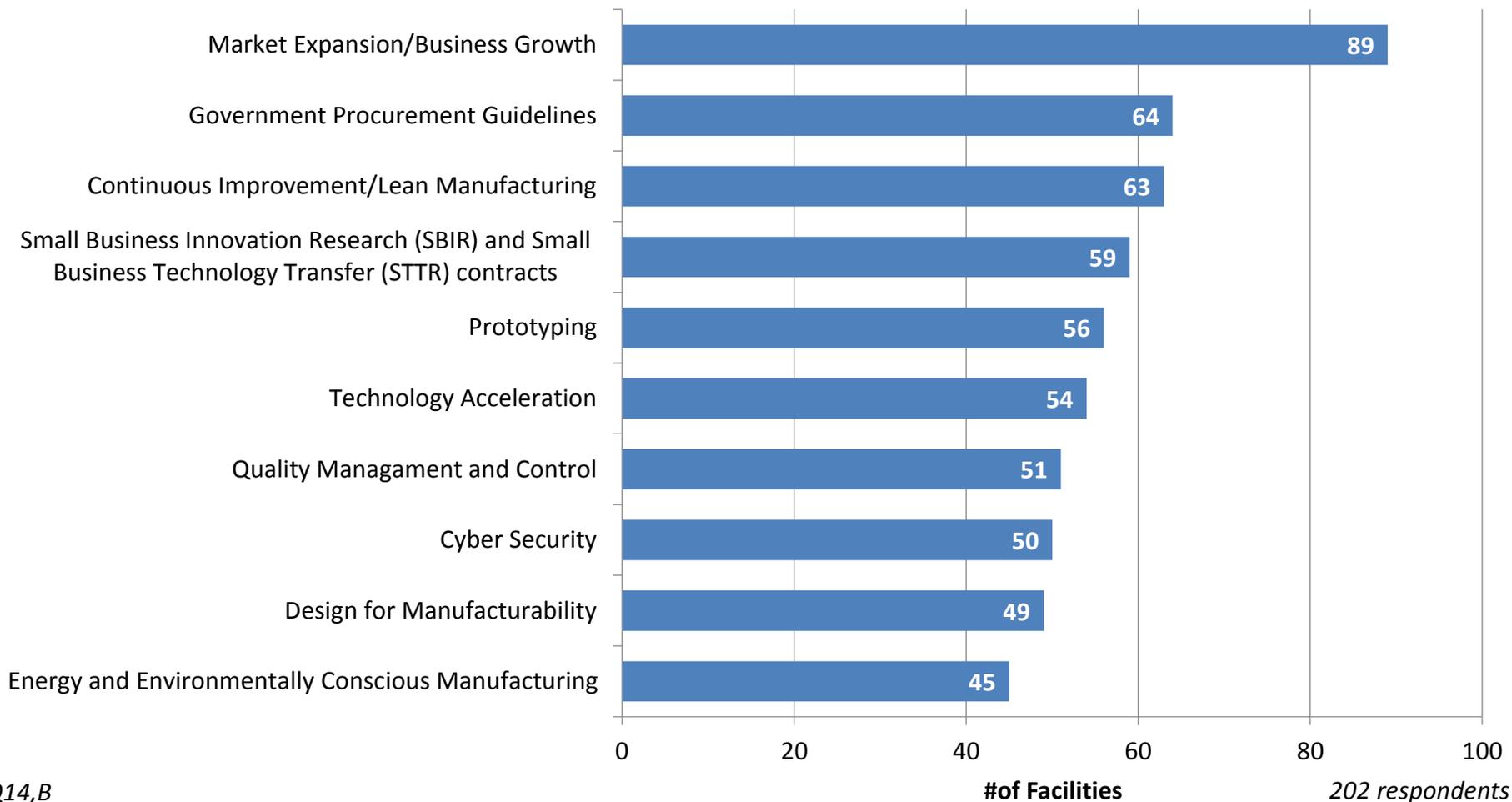
Q12c,A

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

Top Areas of Outreach Interest



Q14,B



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