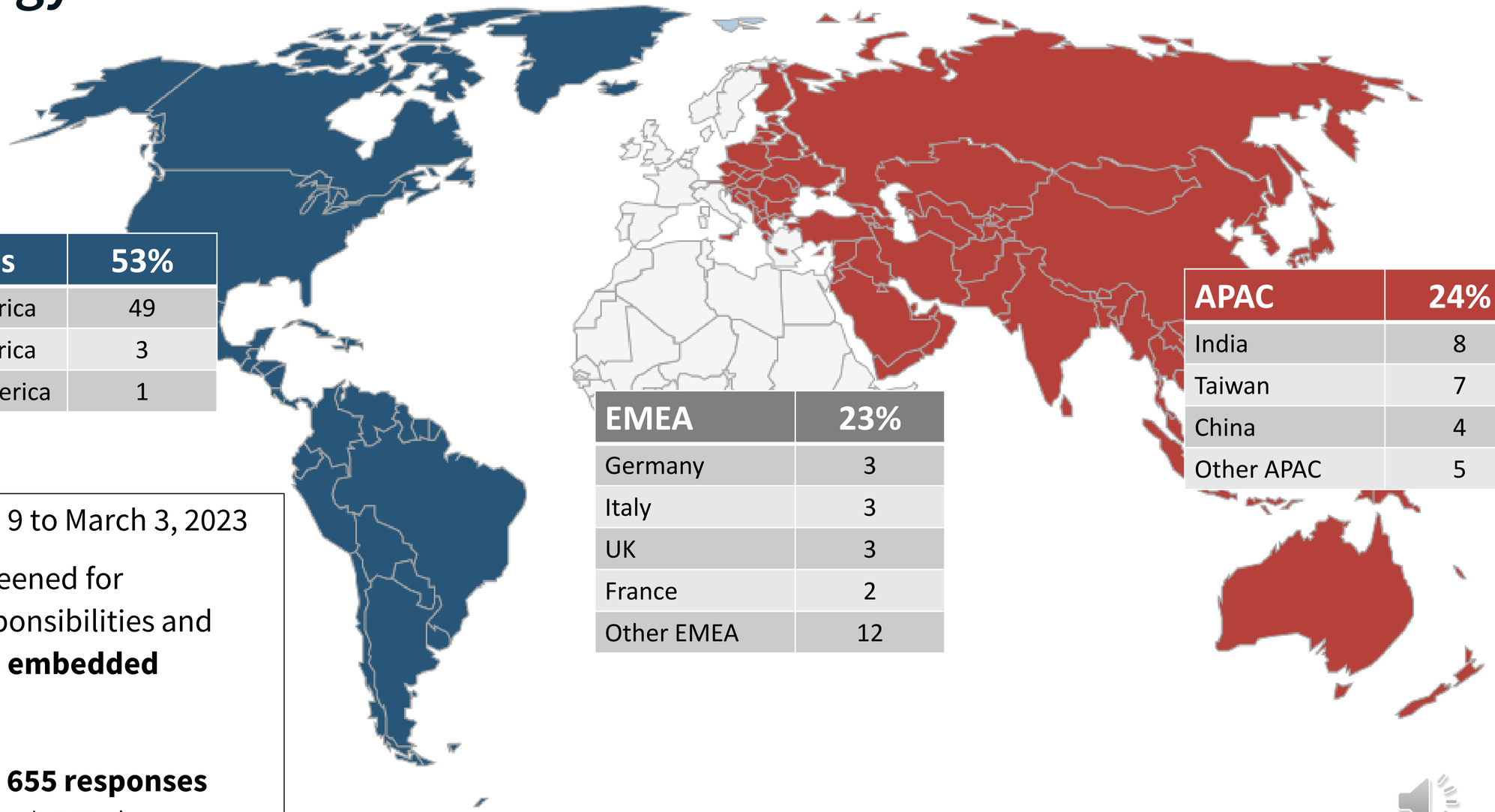
embedded survey

The Current State of Embedded Development

MAY 2023

Methodology

Online survey



Americas	53%
North America	49
South America	3
Central America	1

EMEA	23%
Germany	3
Italy	3
UK	3
France	2
Other EMEA	12

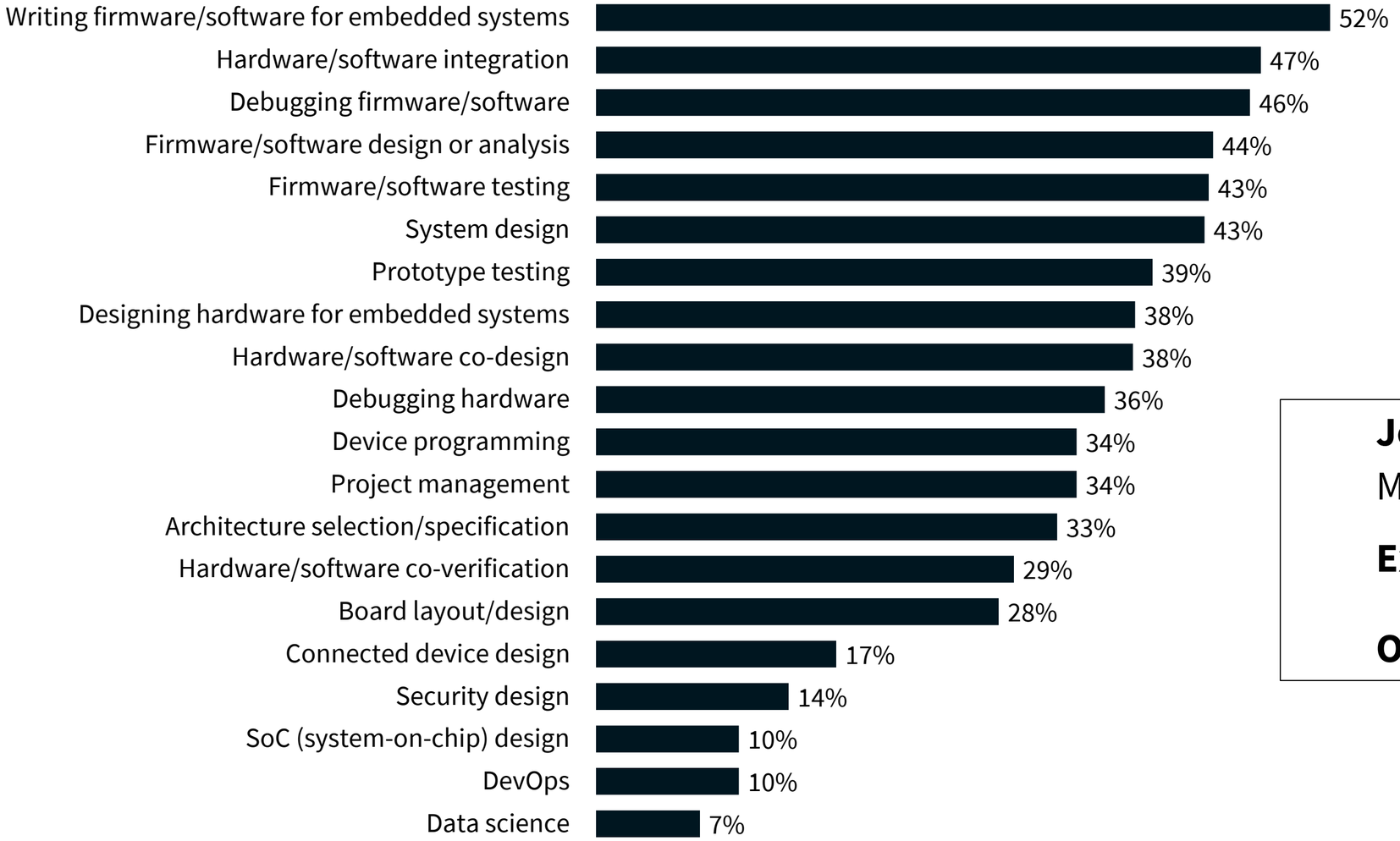
APAC	24%
India	8
Taiwan	7
China	4
Other APAC	5

- **Field Dates**: Feb 9 to March 3, 2023
- Respondents screened for **engineering** responsibilities and **experience with embedded applications**
- Results based on **655 responses** (confidence level +/- 3.7%)

Total Respondents

Respondent Characteristics

Job responsibilities, experience and organization size



Job function: Staff (58%), Management (41%), Other (1%)

Experience: 18.9 years

Organization size: 3,288 employees

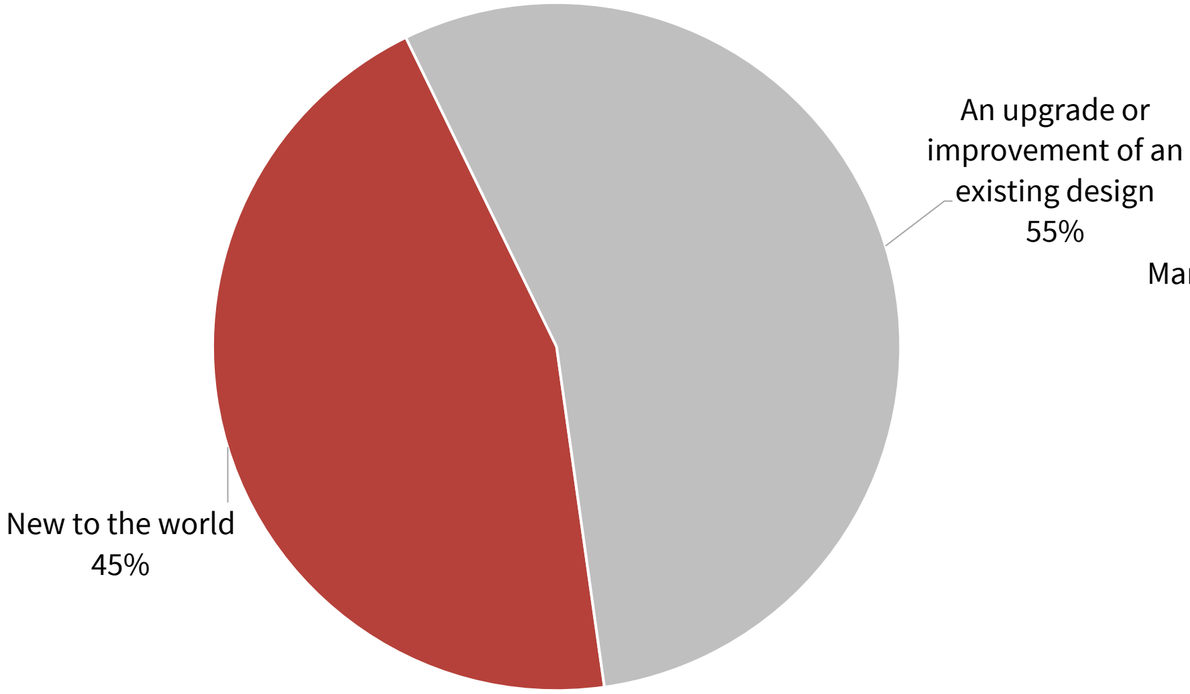
Total Respondents

The Embedded Development Environment

Most embedded projects involve incremental upgrades to existing designs

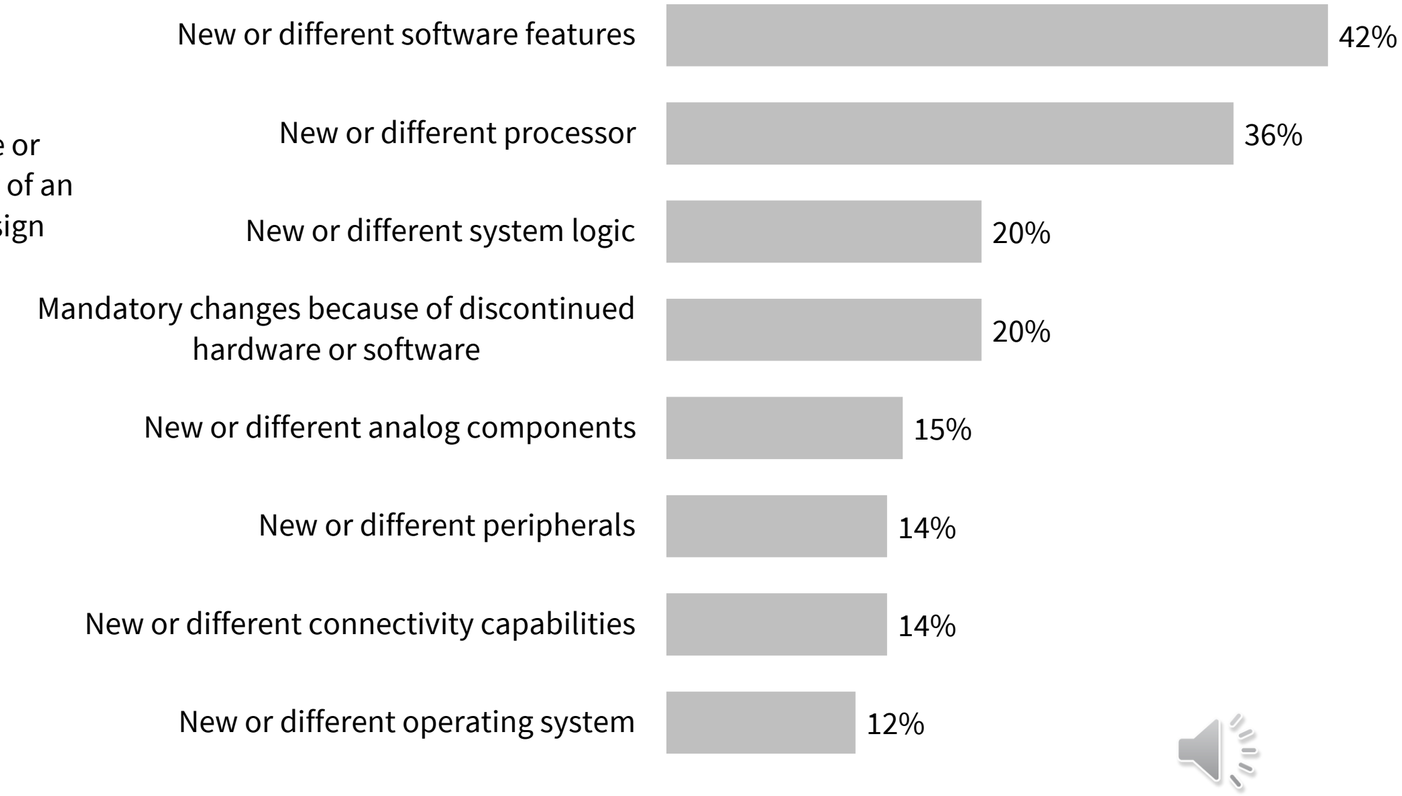
Improvements including additional software features and/or better MPUs/MCUs (particularly by larger OEMs)

Current Embedded Project Is…



Total Respondents

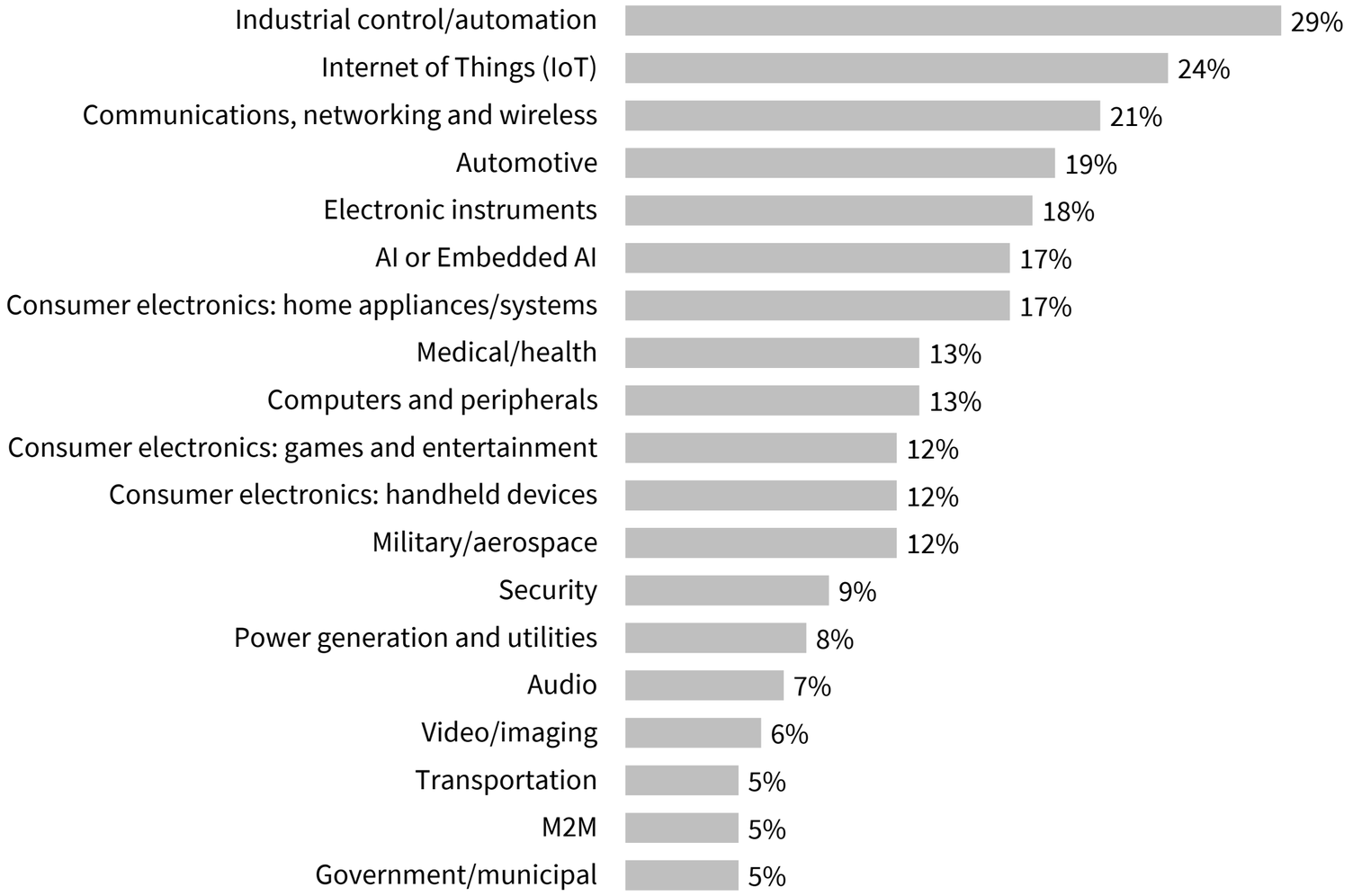
Improvements for Upgrade



Base = Those upgrading existing design (362)

Embedded projects target a wide range of applications

Most projects are developed for *industrial automation and instrumentation, IoT, communications, and automotive*

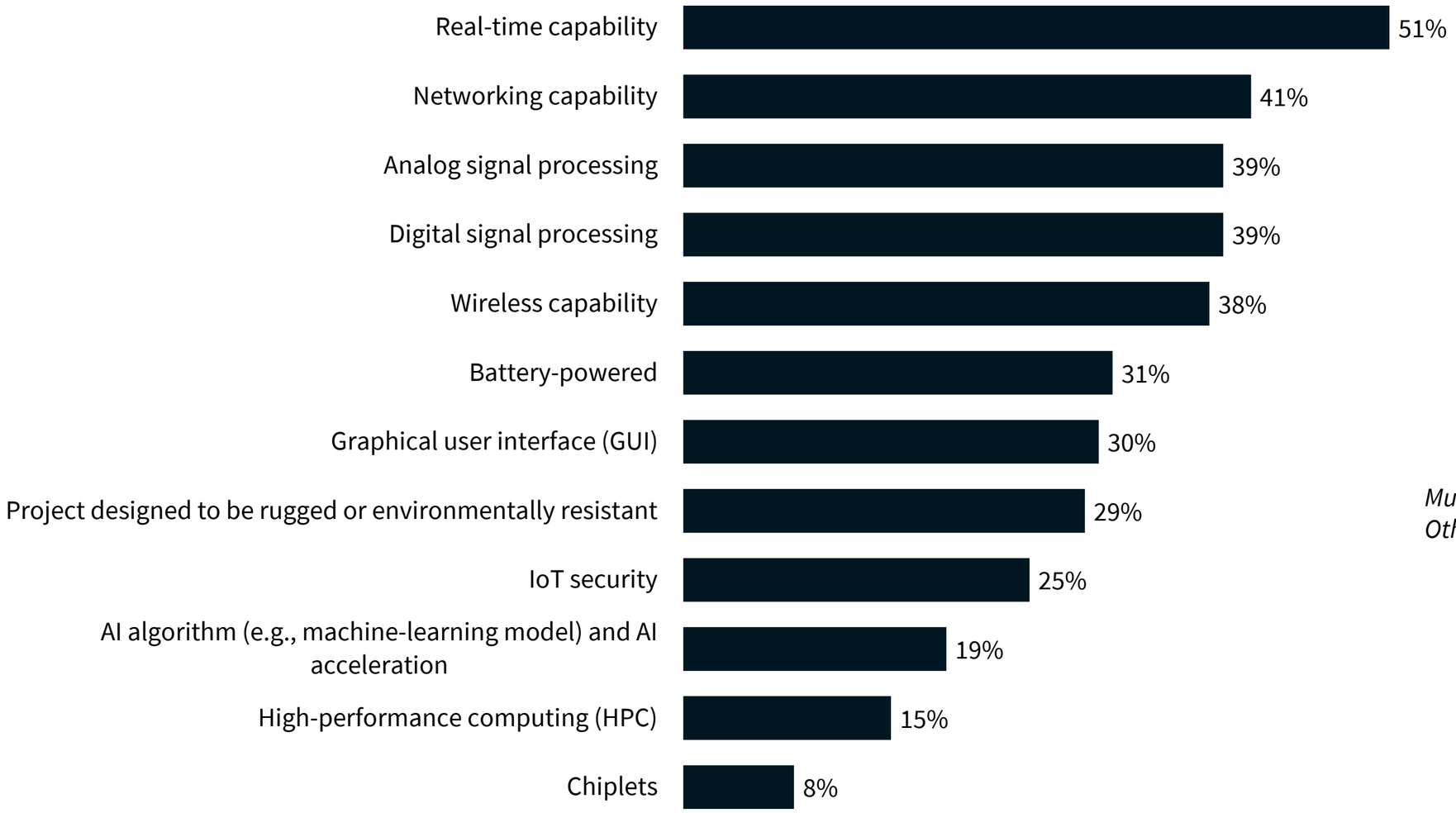


Multiple responses allowed

Total Respondents

Current embedded development devotes considerable attention to performance, connectivity, power efficiency and signal processing

EMEA and APAC teams are particularly interested in these capabilities



Multiple responses allowed
Other = 4%

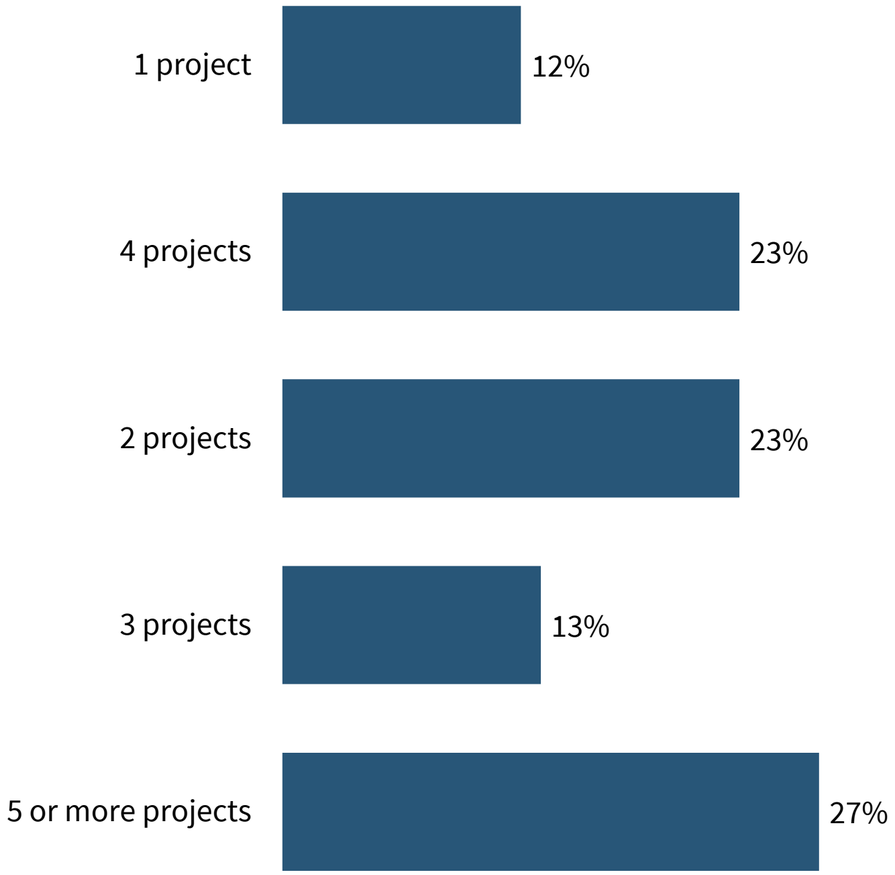
Total Respondents

Embedded development teams have burgeoning workloads

Typical embedded projects take 8 months on average to complete (and longer in larger OEMs and with “new” projects)

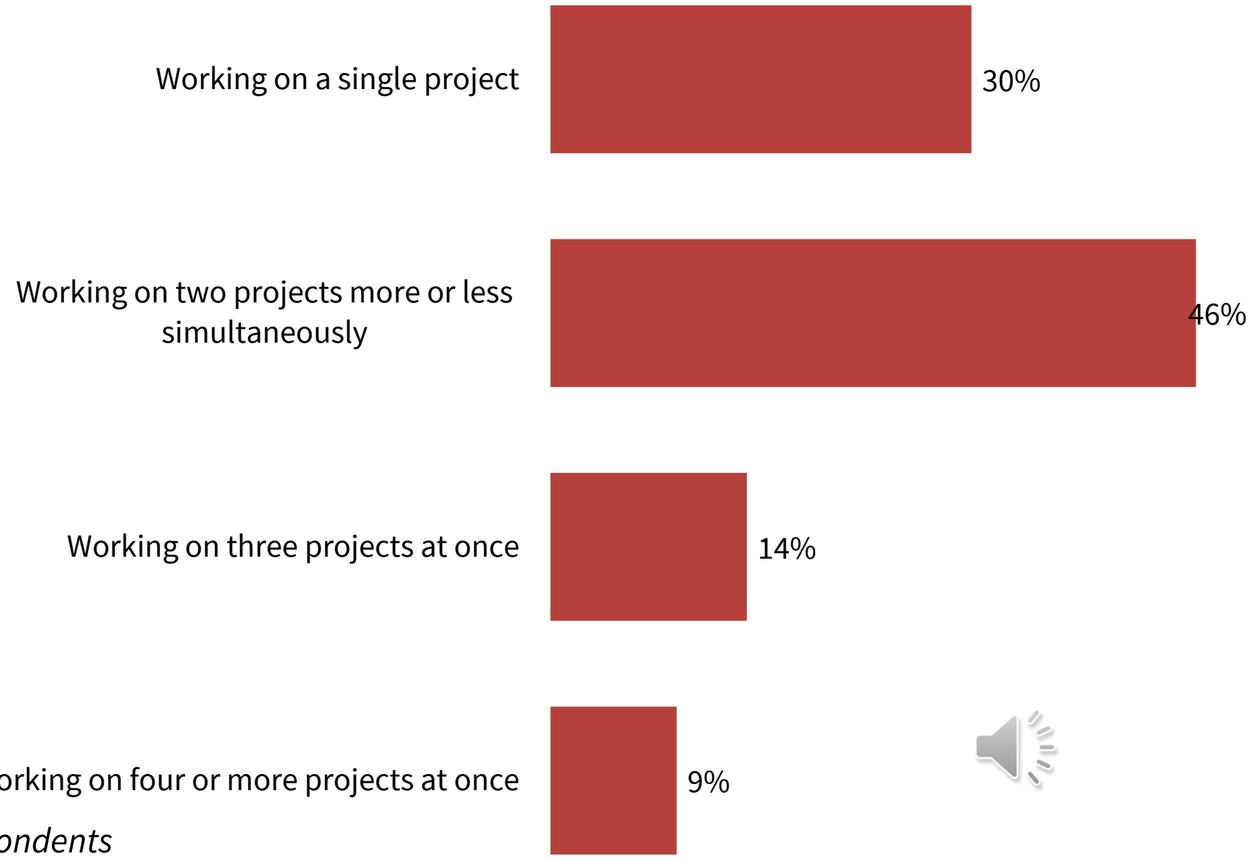
Embedded projects in past year

Average = 4.2 projects



Current embedded projects

Average = 2.1 projects

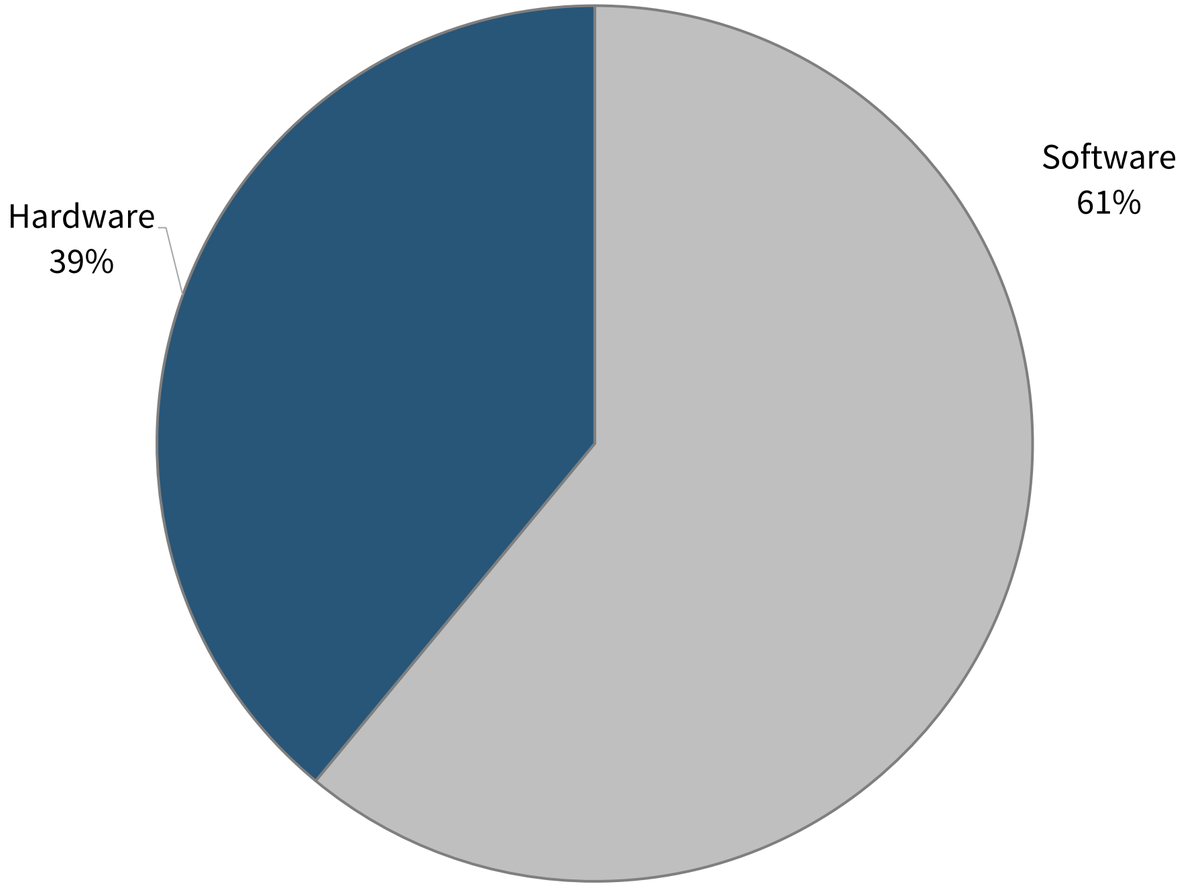


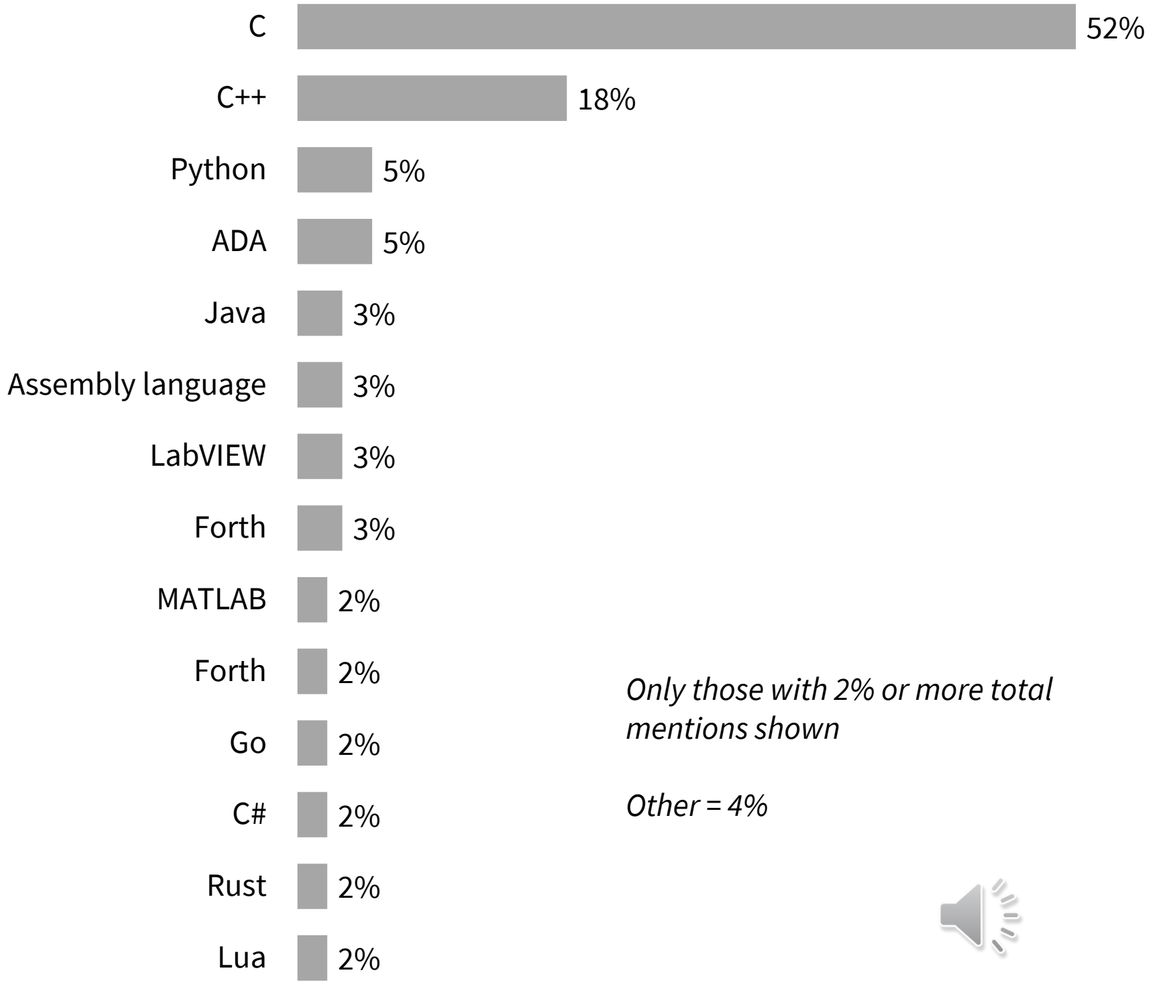
Total Respondents

8. **In the past year, how many embedded projects have you worked on?**
9. **How many embedded projects are you working on right now?**

Software development requires more cycle time

“C” dominates other languages for embedded software programming





Only those with 2% or more total mentions shown

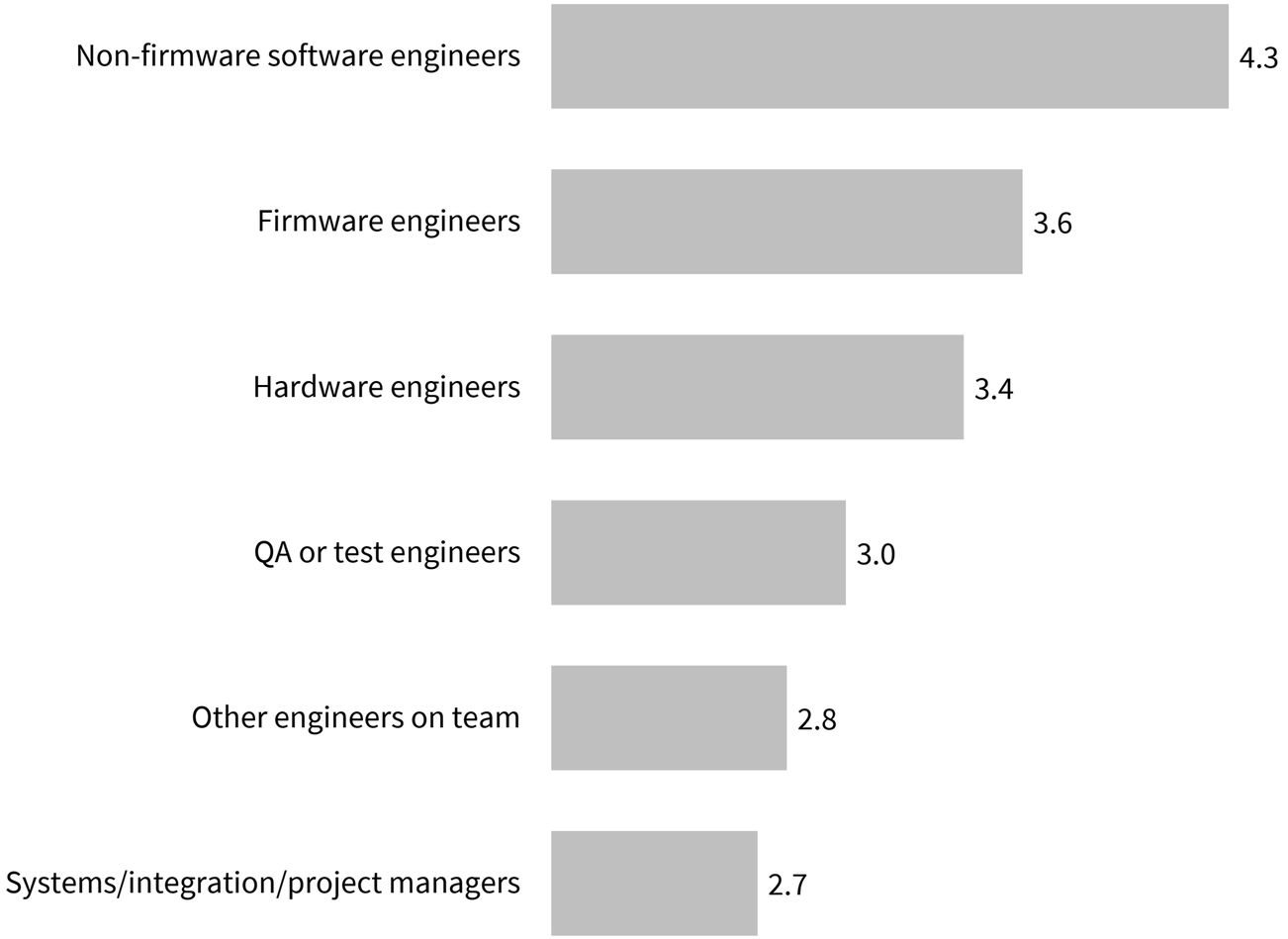
Other = 4%

Total Respondents

10. What is your development team's ratio of total resources (including time/dollars/manpower) spent on software vs. hardware for your embedded projects?
16. My current embedded project is programmed mostly in:

Embedded development teams are large and cover multiple disciplines

Nearly 20 engineers on the team (more in Americas, fewer in EMEA) – with a plurality focused on software/firmware development



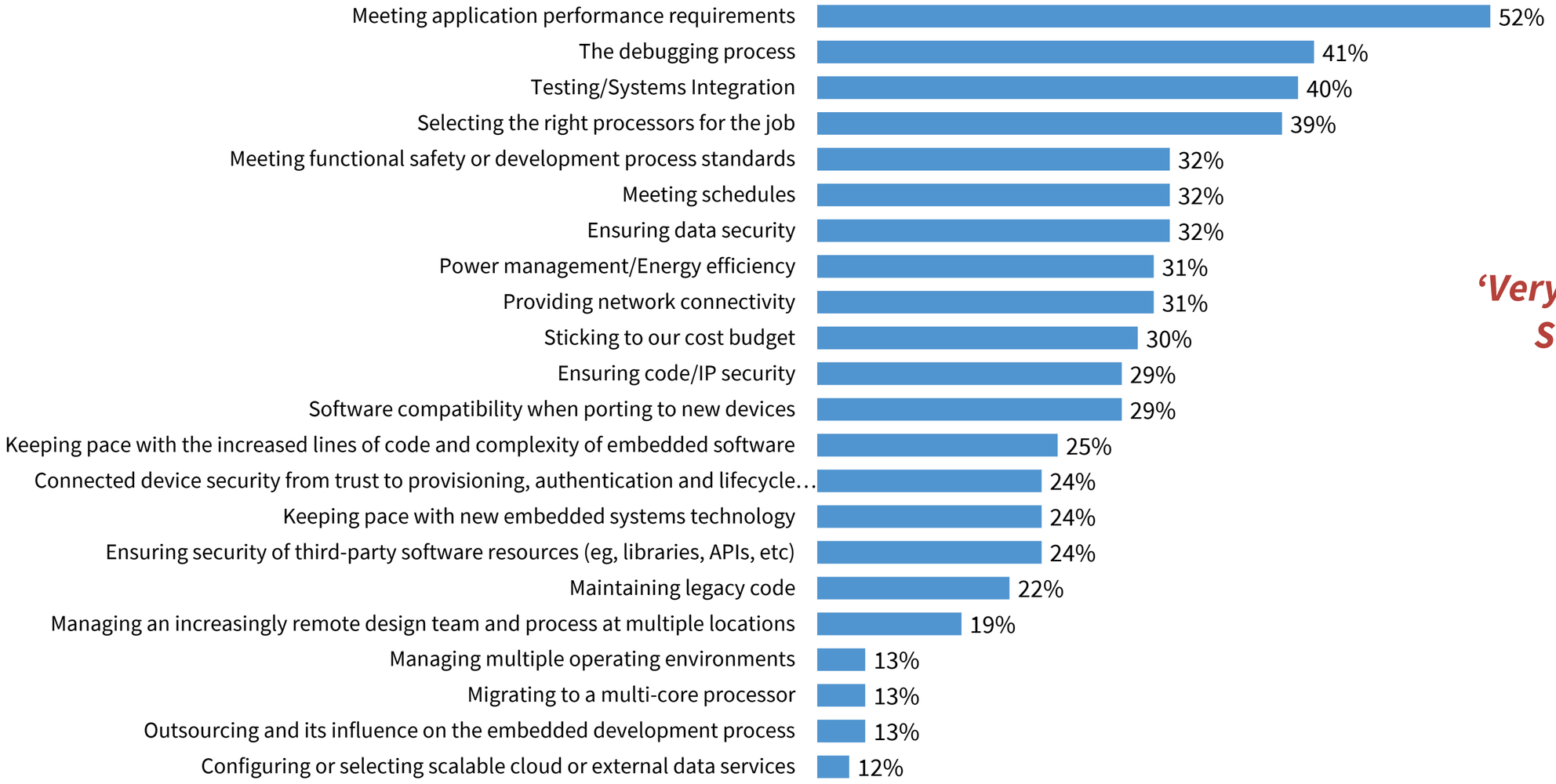
Average engineers per project = 19.8

Mean Scores

Total Respondents

Meeting performance specs, processor choice and test/debugging are critical issues

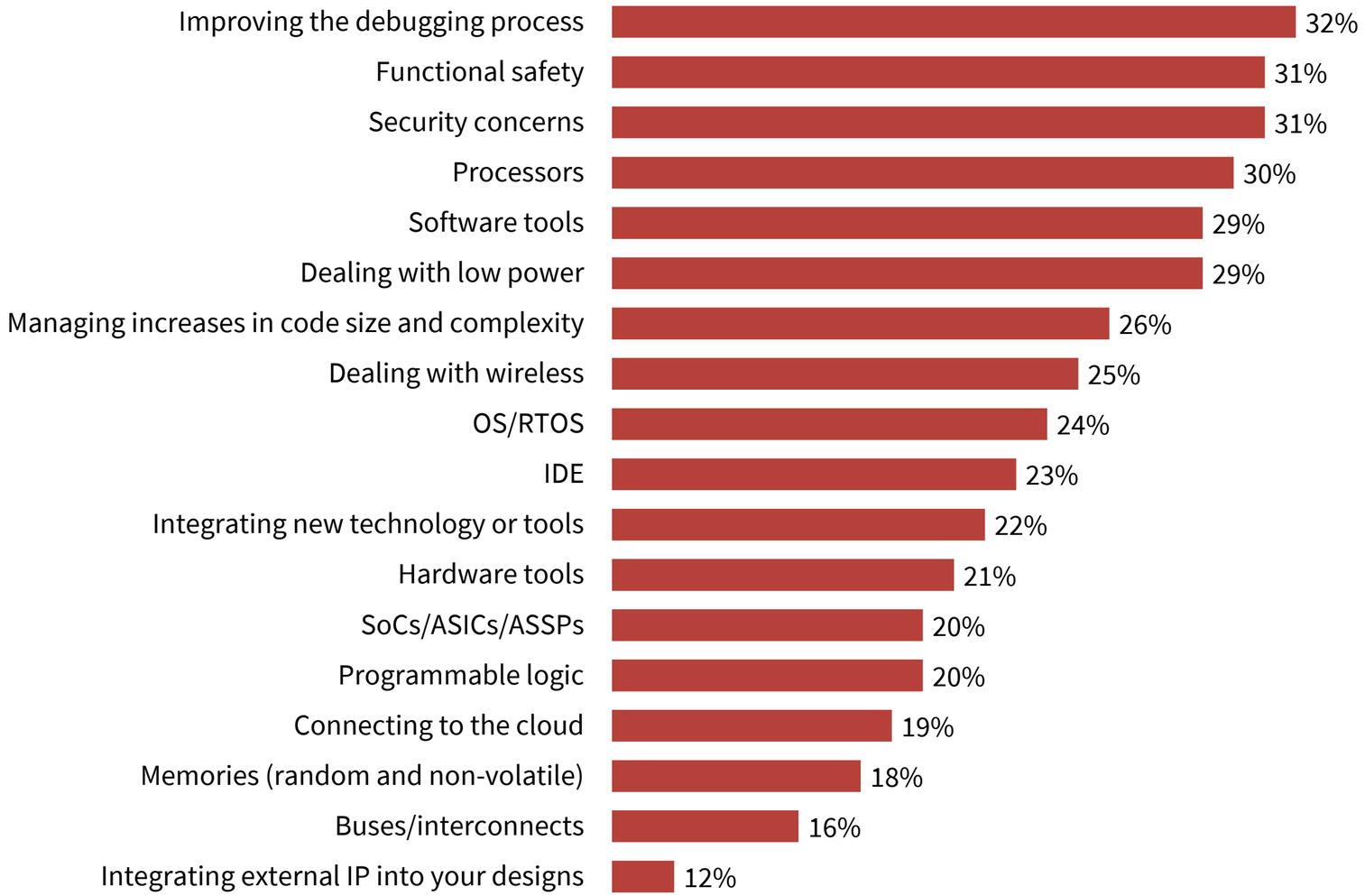
Safety, security and power management are also high on the agenda (especially for EMEA and APAC designers)



'Very Important' Summary

Total Respondents

Better debugging and SW tools, improved safety and security and power join processor selection as most critical design challenges



APAC design teams are especially concerned about nearly all these issues

'Very Important' Summary

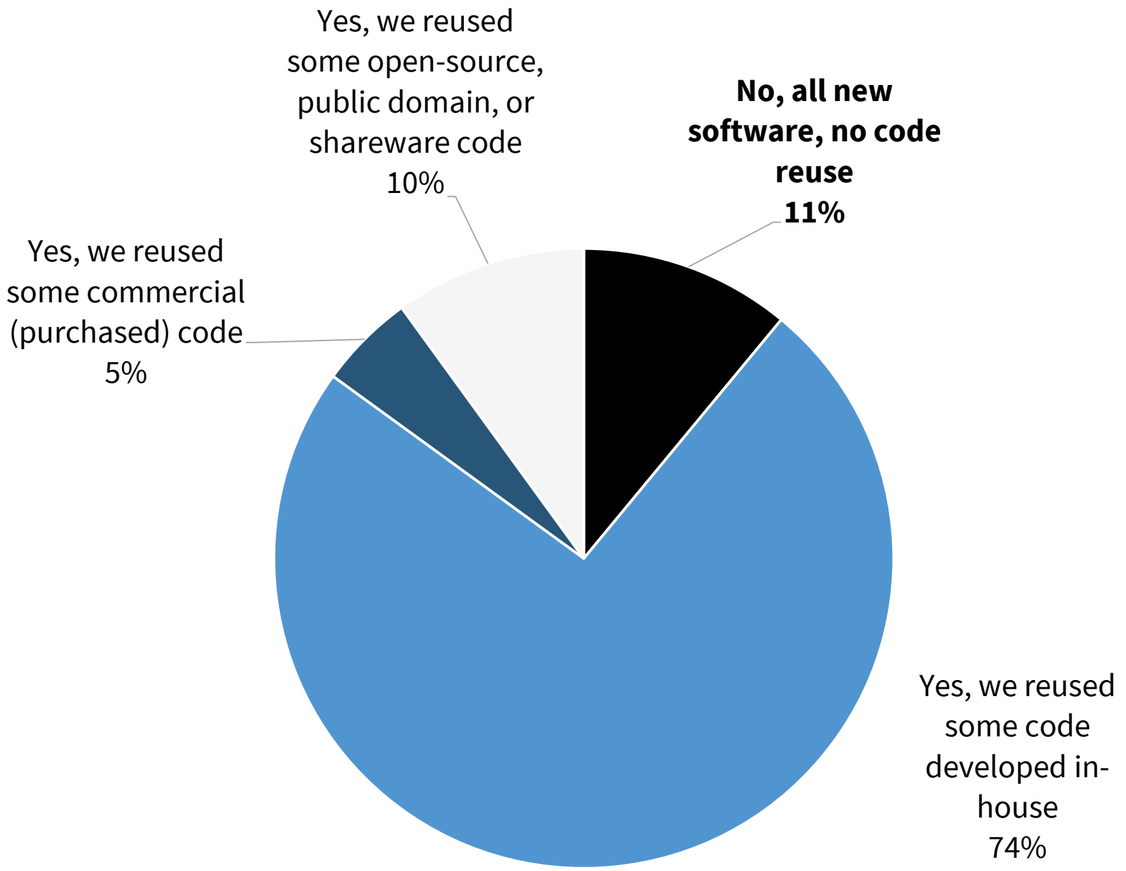
Total Respondents

Reuse of software code, hardware and HW IP is the norm

Proprietary software code reuse is somewhat more common than hardware or IP reuse

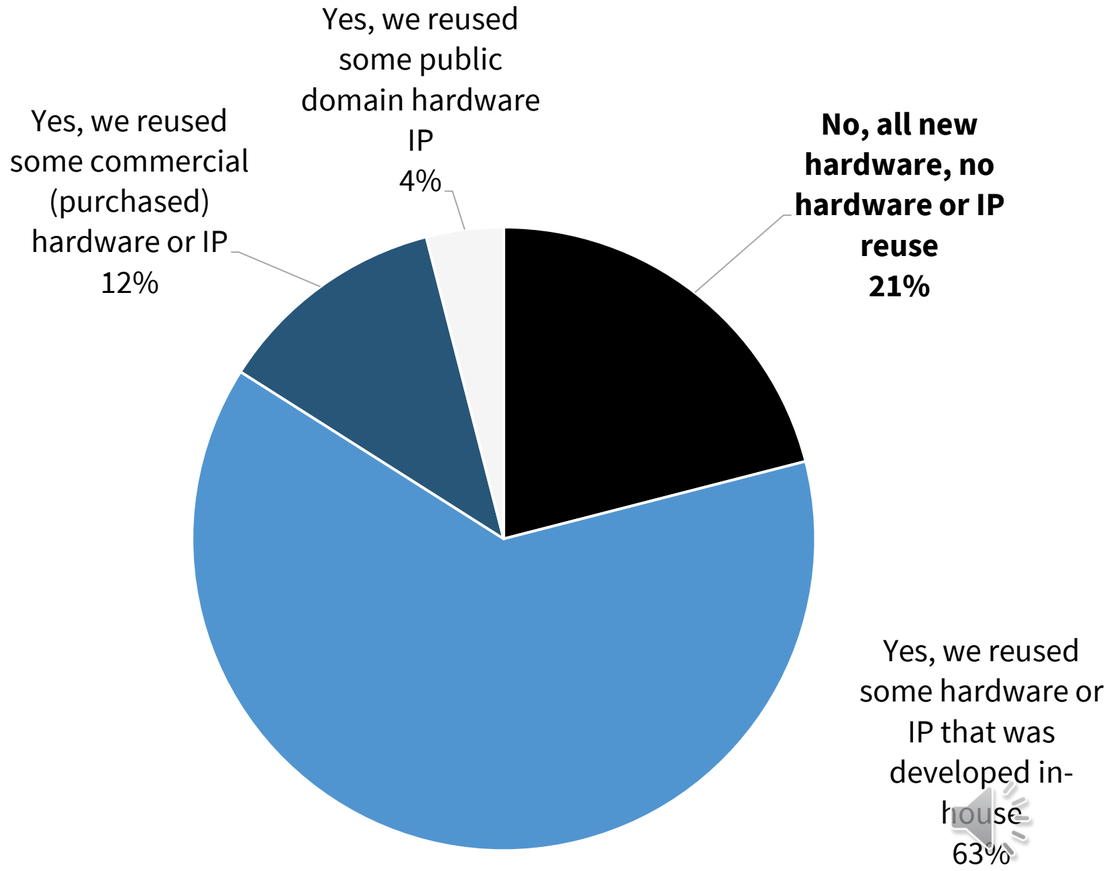
Software Reuse = 89%

2019 = 88%



Hardware Reuse = 79%

2019 = 77%

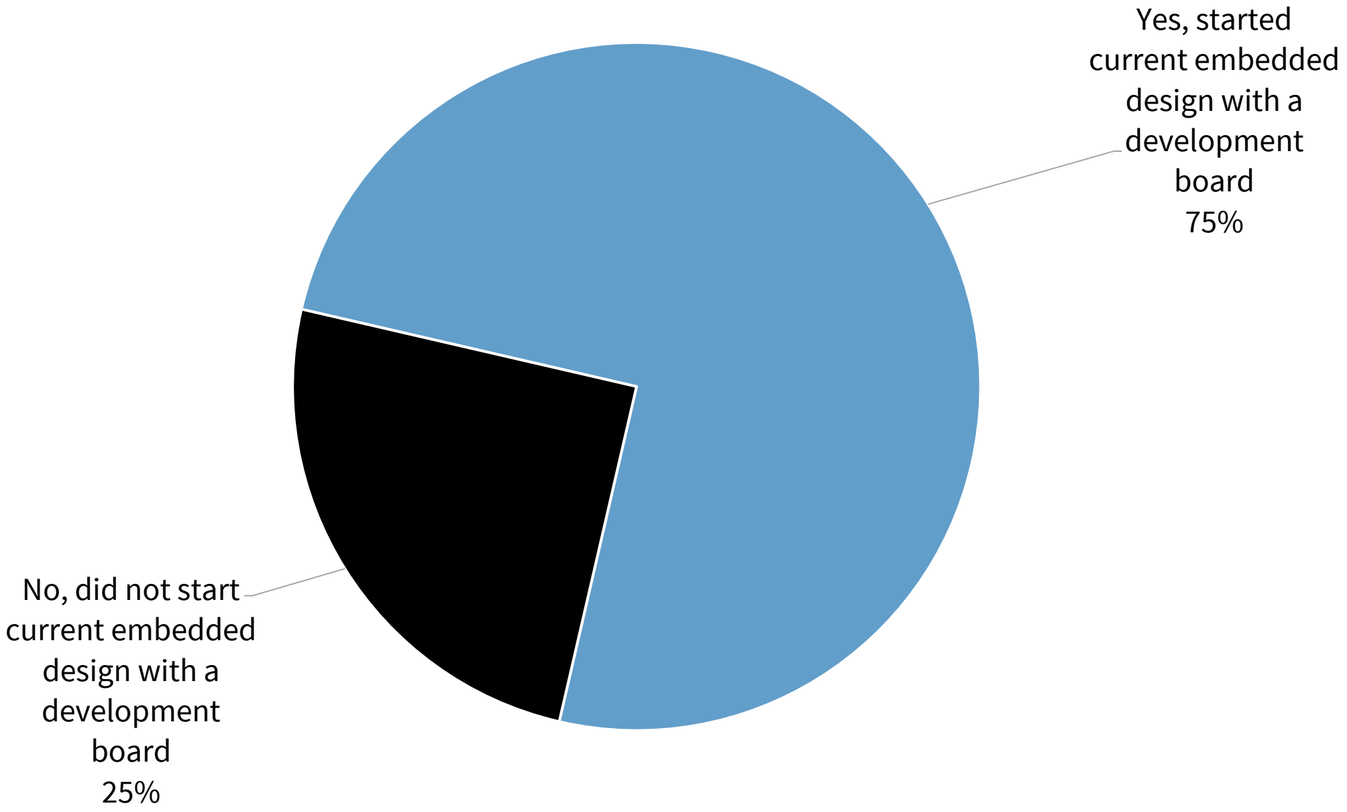


Total Respondents

Use of development boards in embedded design is widespread

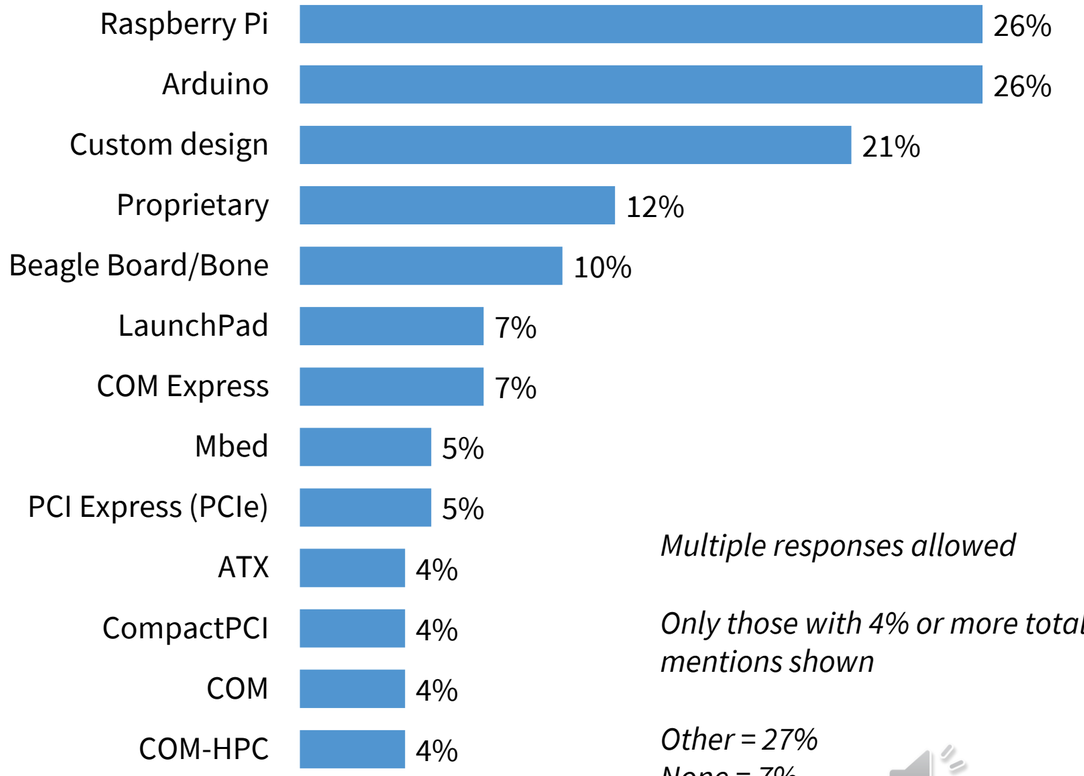
Among those using development boards, more than half use *Raspberry Pi* and *Arduino*

Development Board Use when Starting Embedded Projects



Total Respondents

Board Used in Current Design(s)



Multiple responses allowed

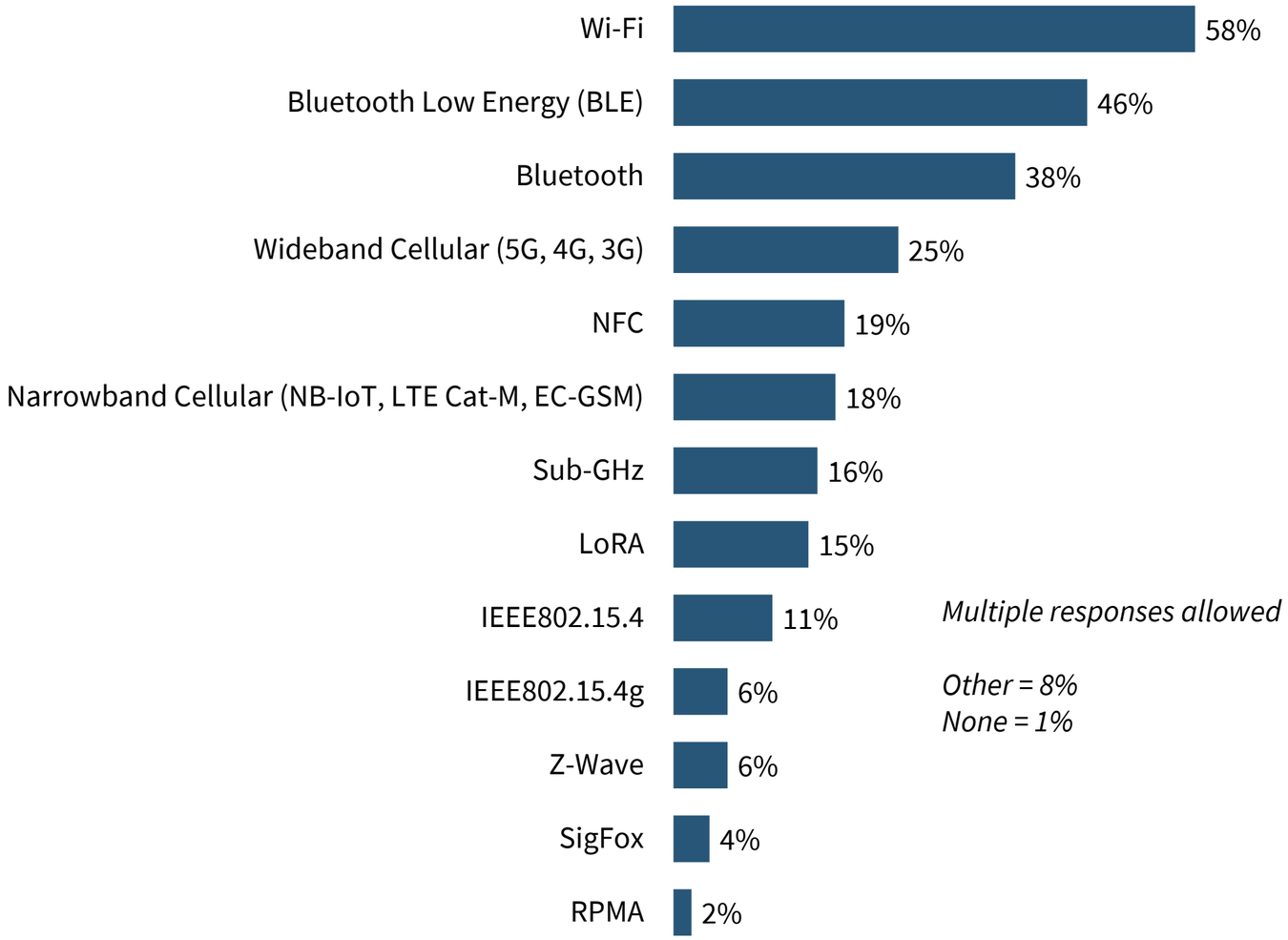
Only those with 4% or more total mentions shown

Other = 27%
None = 7%

Base = Those using development board 488()

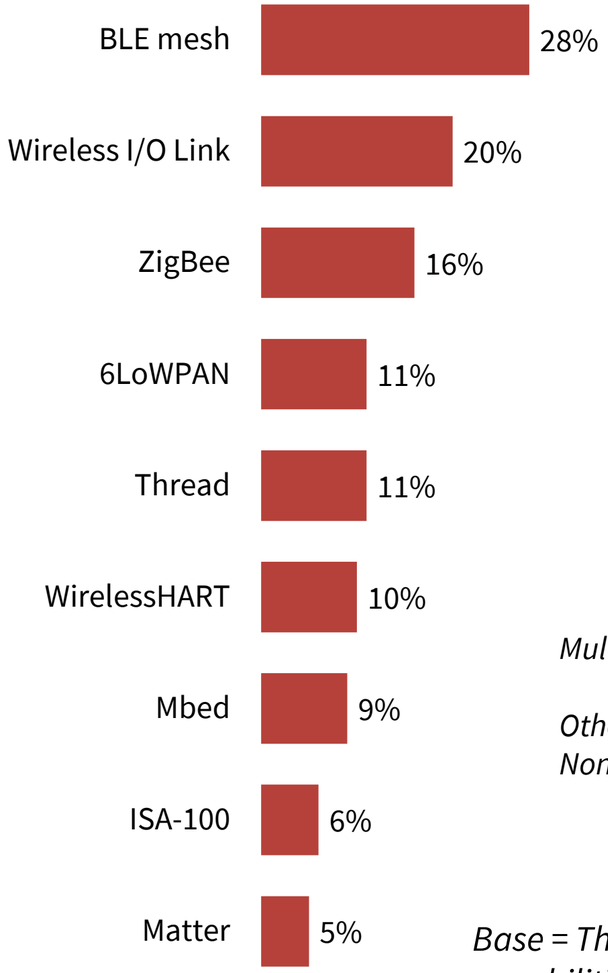
Over one-third of embedded designs incorporate wireless capabilities

Wi-Fi and Bluetooth are the most used interfaces and Bluetooth Low Energy mesh the most popular protocol



Multiple responses allowed

Other = 8%
None = 1%



Multiple responses allowed

Other = 13%
None = 36%

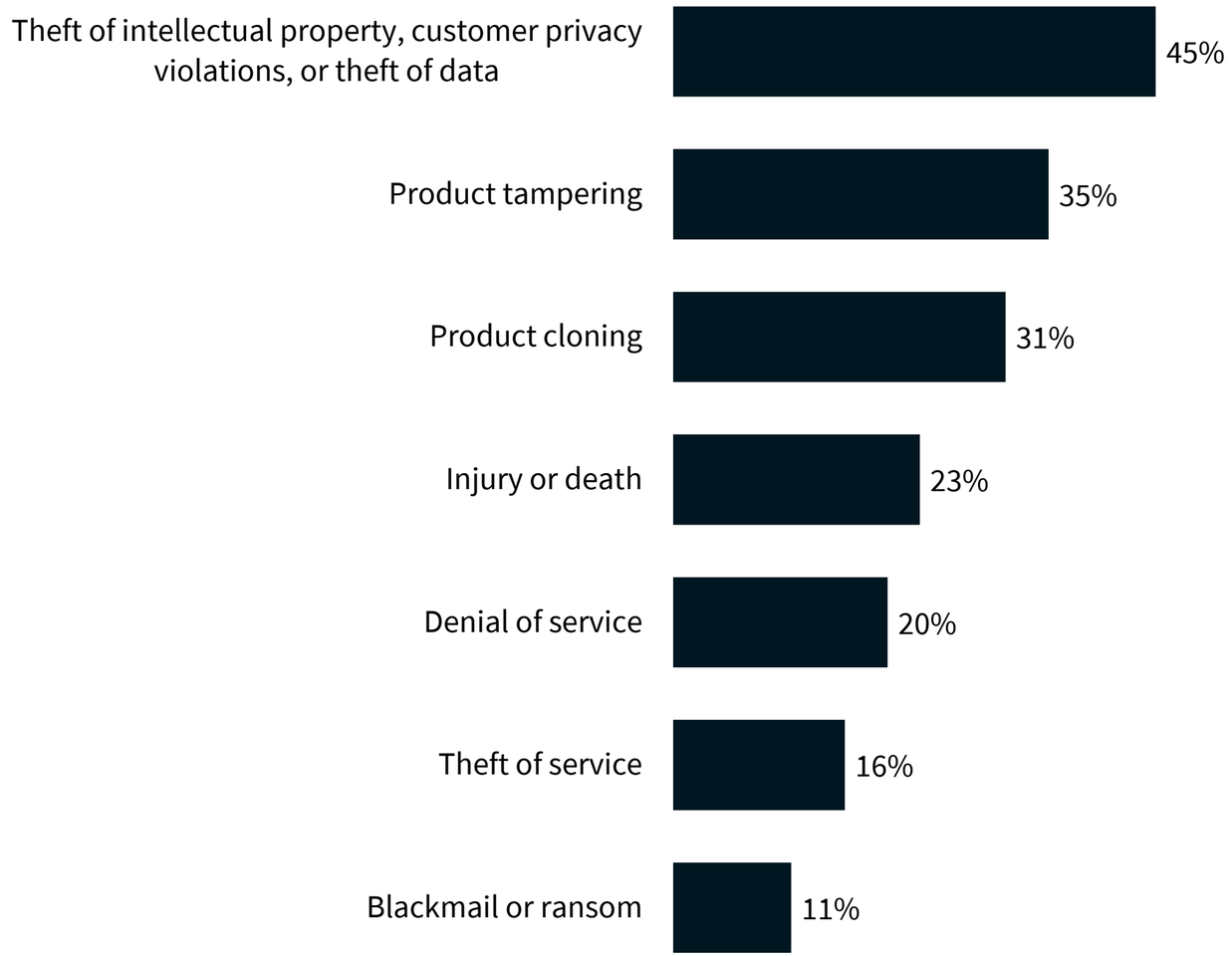
Base = Those using 'wireless capabilities' in a current project (251)

embedded survey

4. **What wireless interfaces does your current project include?**
5. **What wireless protocols/stacks does your current project include?**

Embedded design requires attention to security

IP theft, product tampering, and cloning are primary issues, especially for larger OEMs



Multiple responses allowed

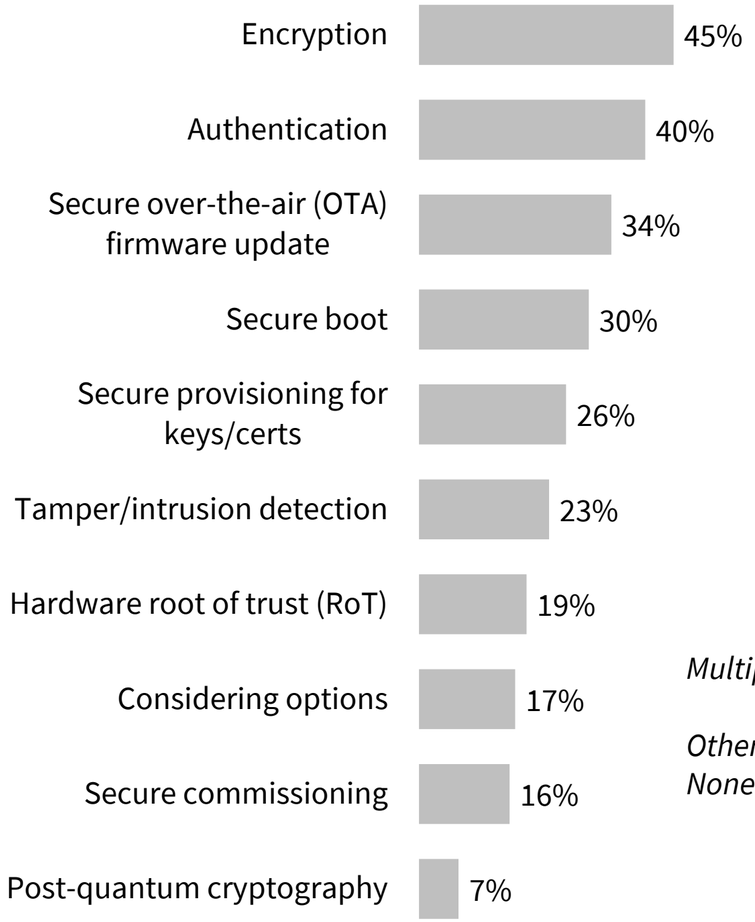
Other = 2%
None = 9%

Total Respondents

Embedded design teams utilize multiple security solutions

Encryption, authentication and secure “over the air” firmware updates, along with MCU security features are most relied on

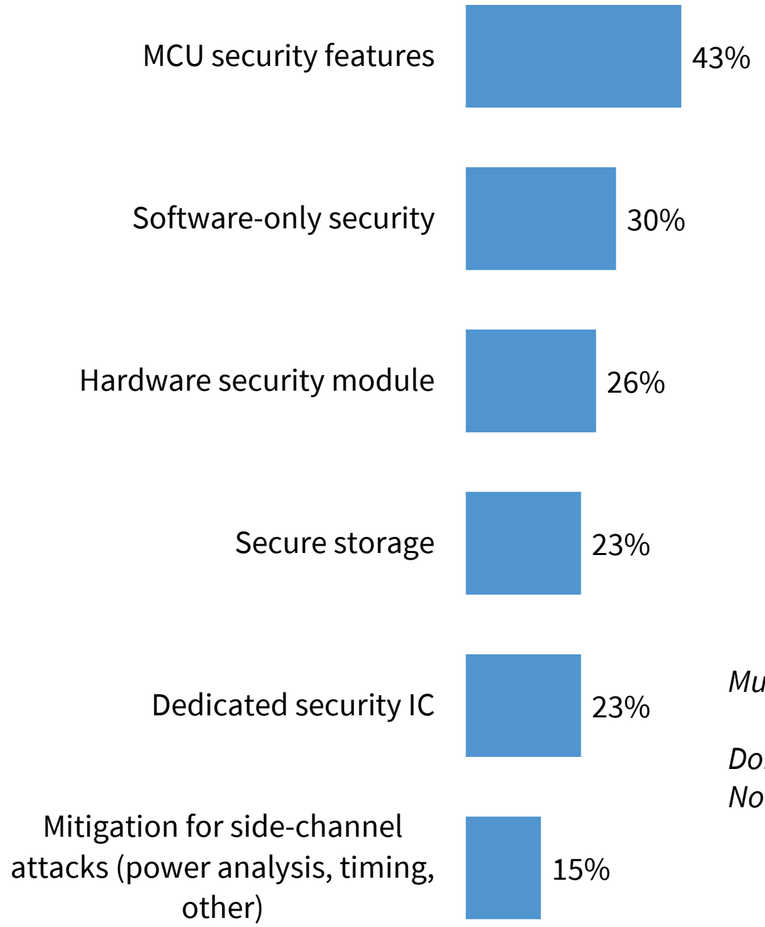
Security measures



Multiple responses allowed

Other = 3%
None = 3%

Hardware support for security



Multiple responses allowed

Don’t know =6%
None = 10%

Total Respondents

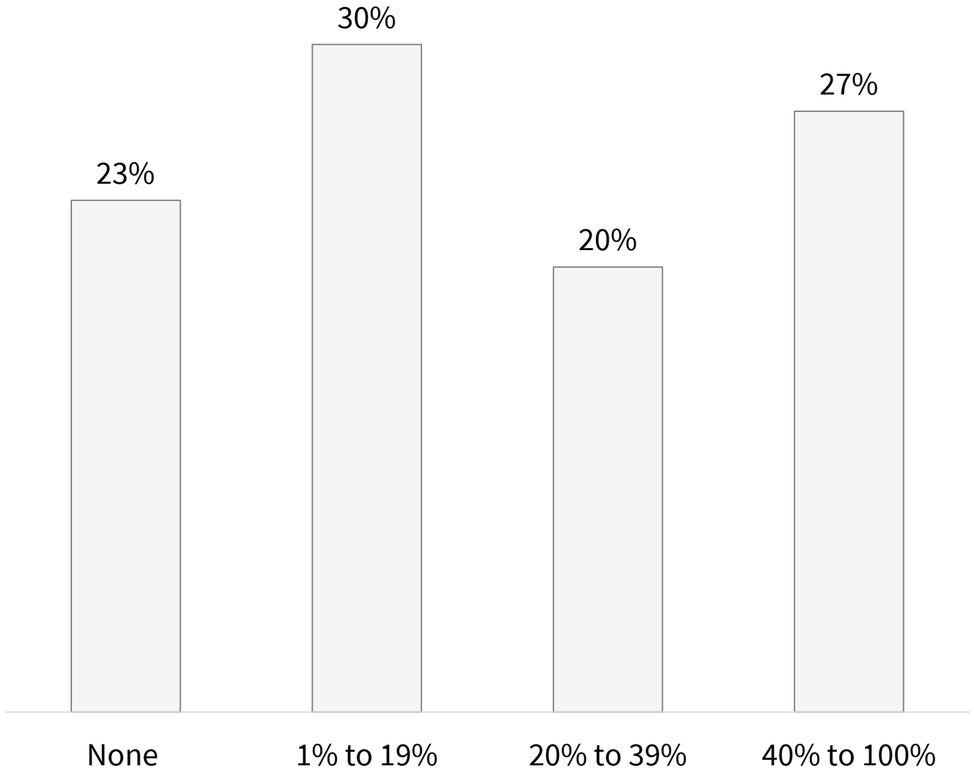
Internet of Things (IoT) continues to attract attention

Nearly one-third of embedded design is devoted wholly or partially to IoT, most for sensor-driven, industrial or mobile communications applications

Projects devoted to IoT

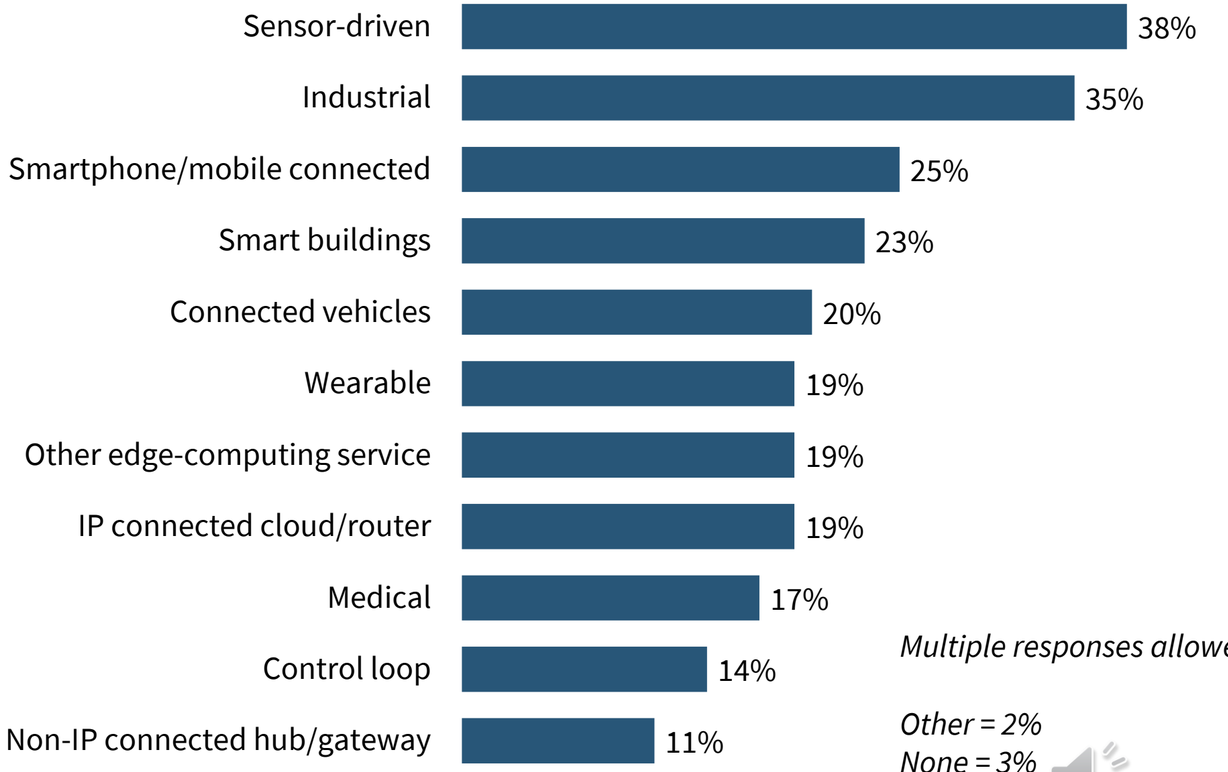
Mean = 29% of projects

2019 = 21% of projects



Total Respondents

Types of Applications for IoT



Multiple responses allowed

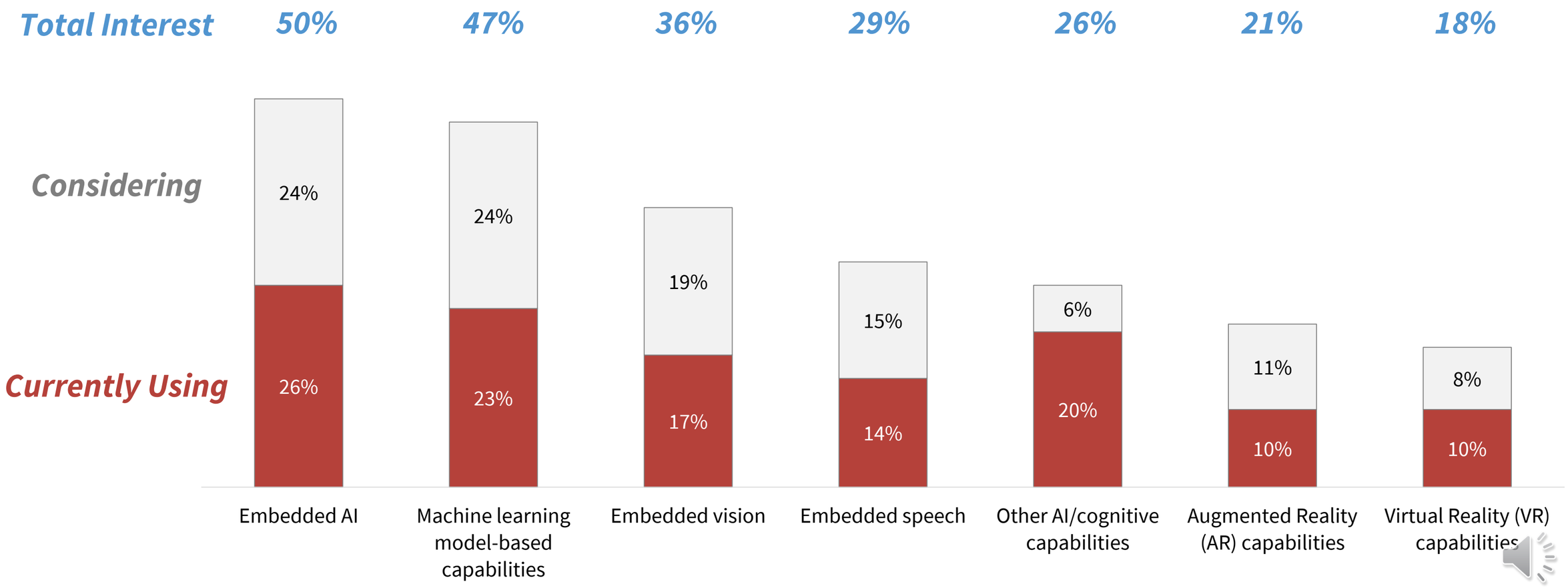
Other = 2%
None = 3%

Base = Those primary devoted to IoT applications (870)

24. In the coming year, approximately what percentage of your projects will be primarily devoted to Internet of Things (IoT) applications or devices?
25. If you are developing Internet of Things (IoT) applications, please indicate the types of applications.

Embedded development makes use of advanced technology capabilities

Embedded AI and machine learning attract the most attention, followed by embedded vision and speech capabilities



Total Respondents

27. Which of the following advanced technologies are you currently using in your embedded systems?
28. Which of the following advanced technologies are you considering using in your future embedded systems?

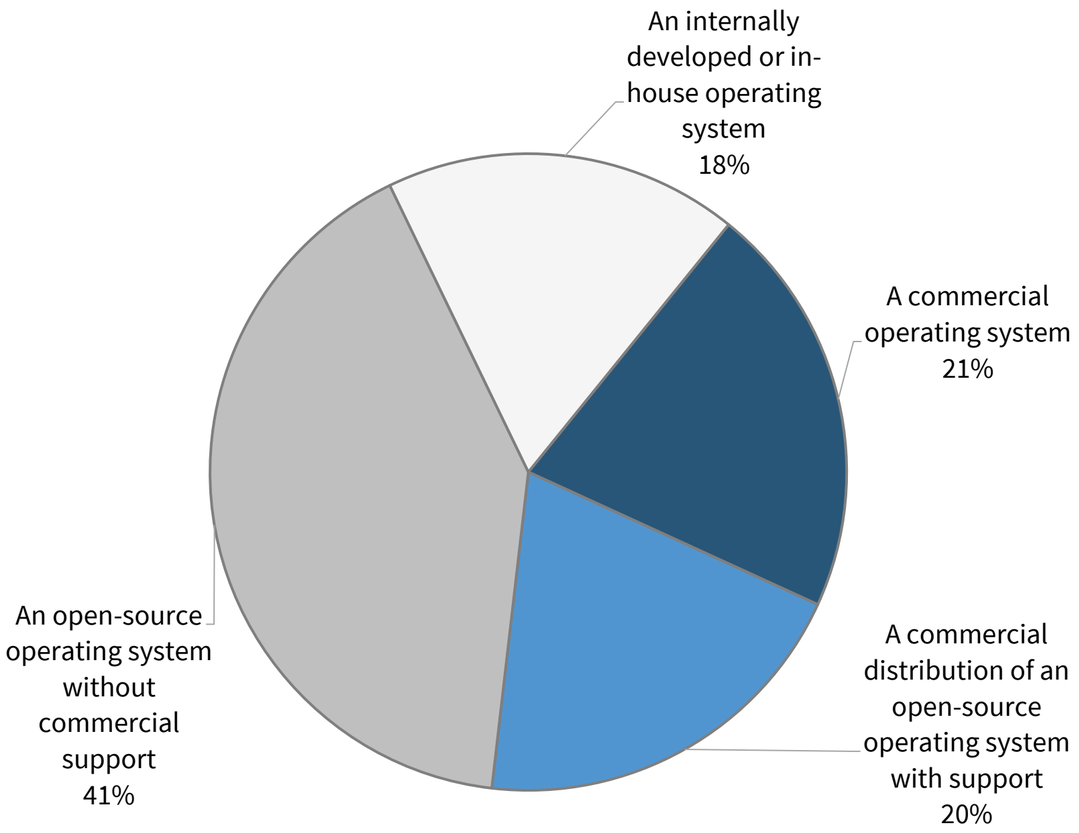
Operating Systems

Most embedded projects utilize an operating system

Although open source is popular, four in ten use either commercial OS or open-source OS distributed commercially

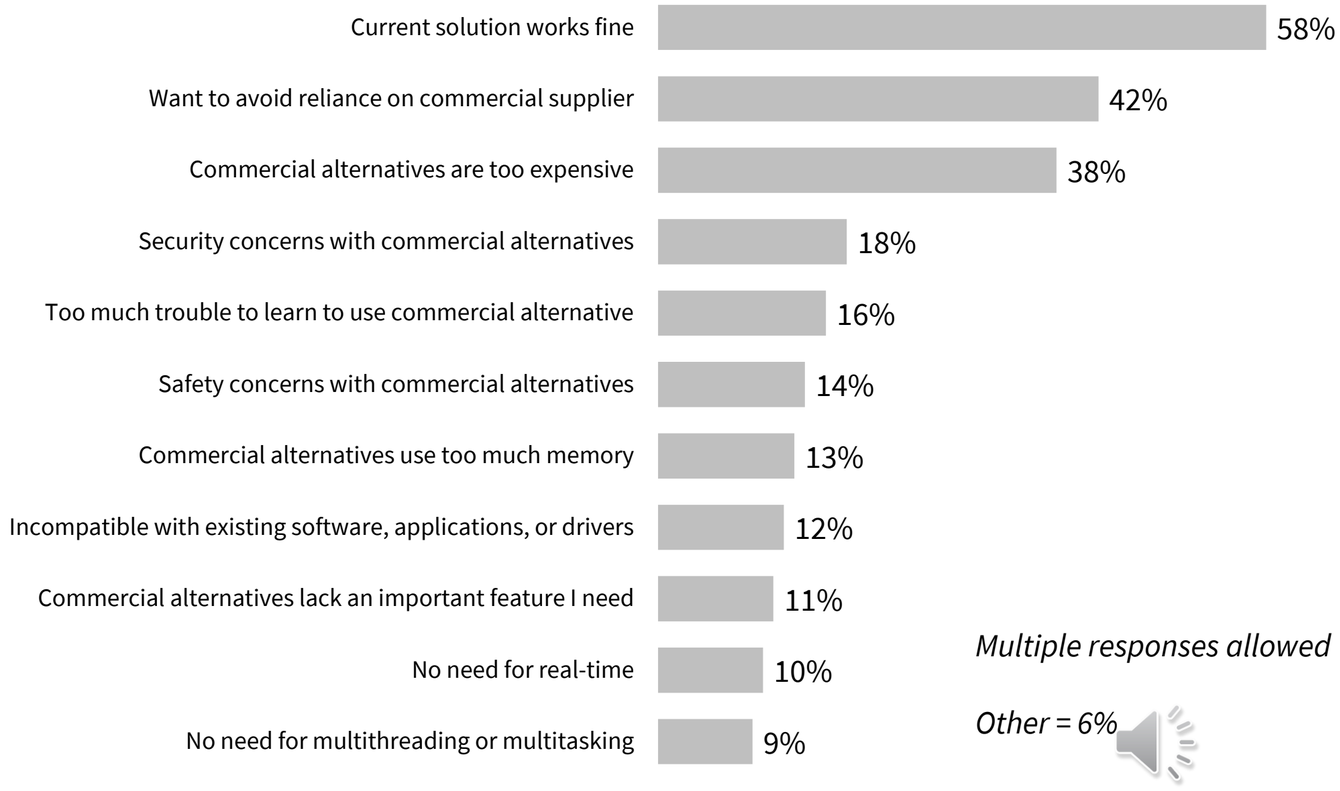
74% use an OS in current embedded project

OS Used in Current Embedded Project



Total Respondents

Reasons for not using commercial OS



Multiple responses allowed

Other = 6%

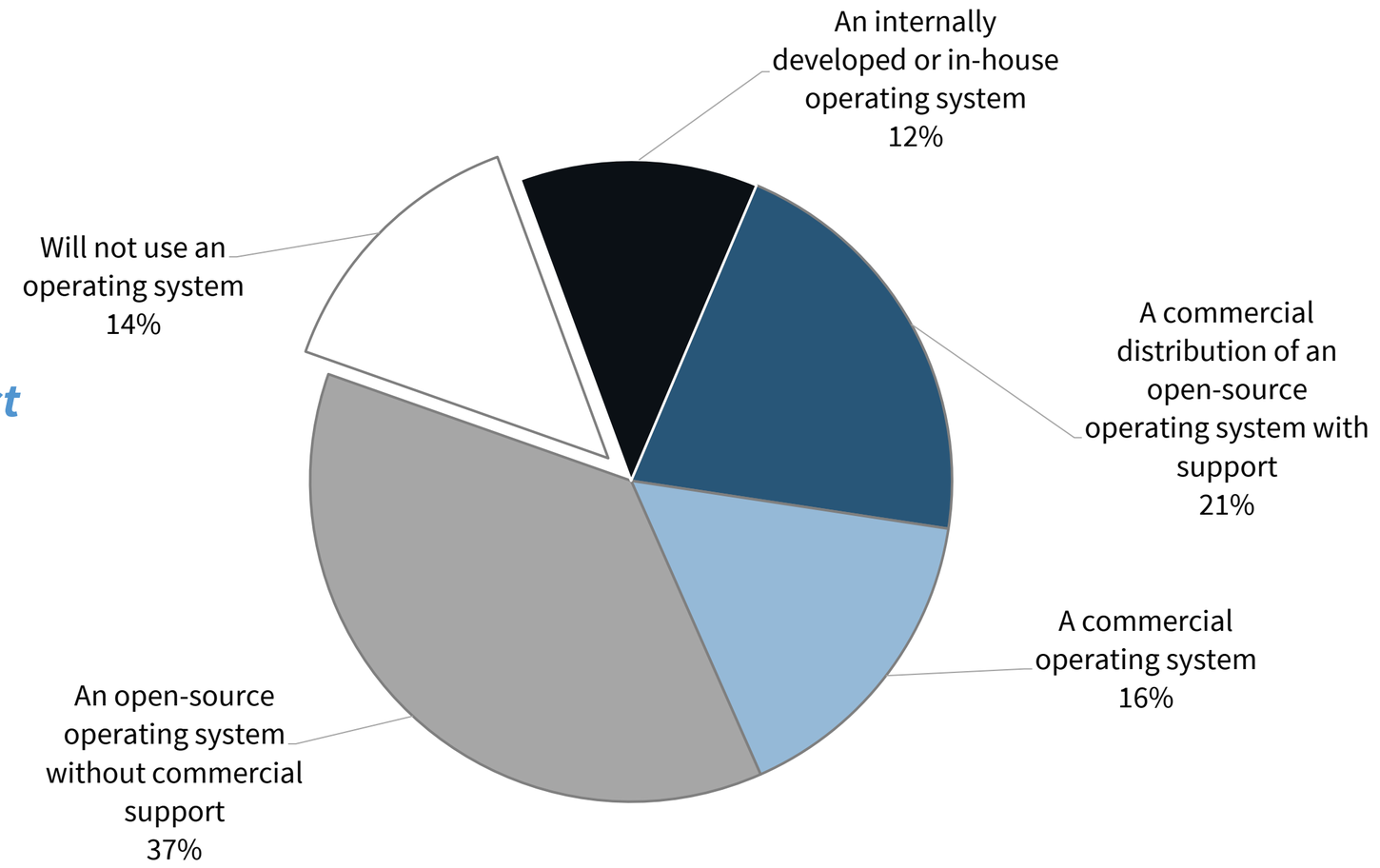
Base = Those not using commercial OS (284)

29. Does your current embedded project use an operating system, RTOS, kernel, software executive, or scheduler of any kind?
30. My current embedded project uses:
31. 31. What are your reasons for NOT currently using a commercial operating system?

OS use will increase, but open-source share will grow

Nearly 30% of those now using commercial OS are considering open-source alternatives

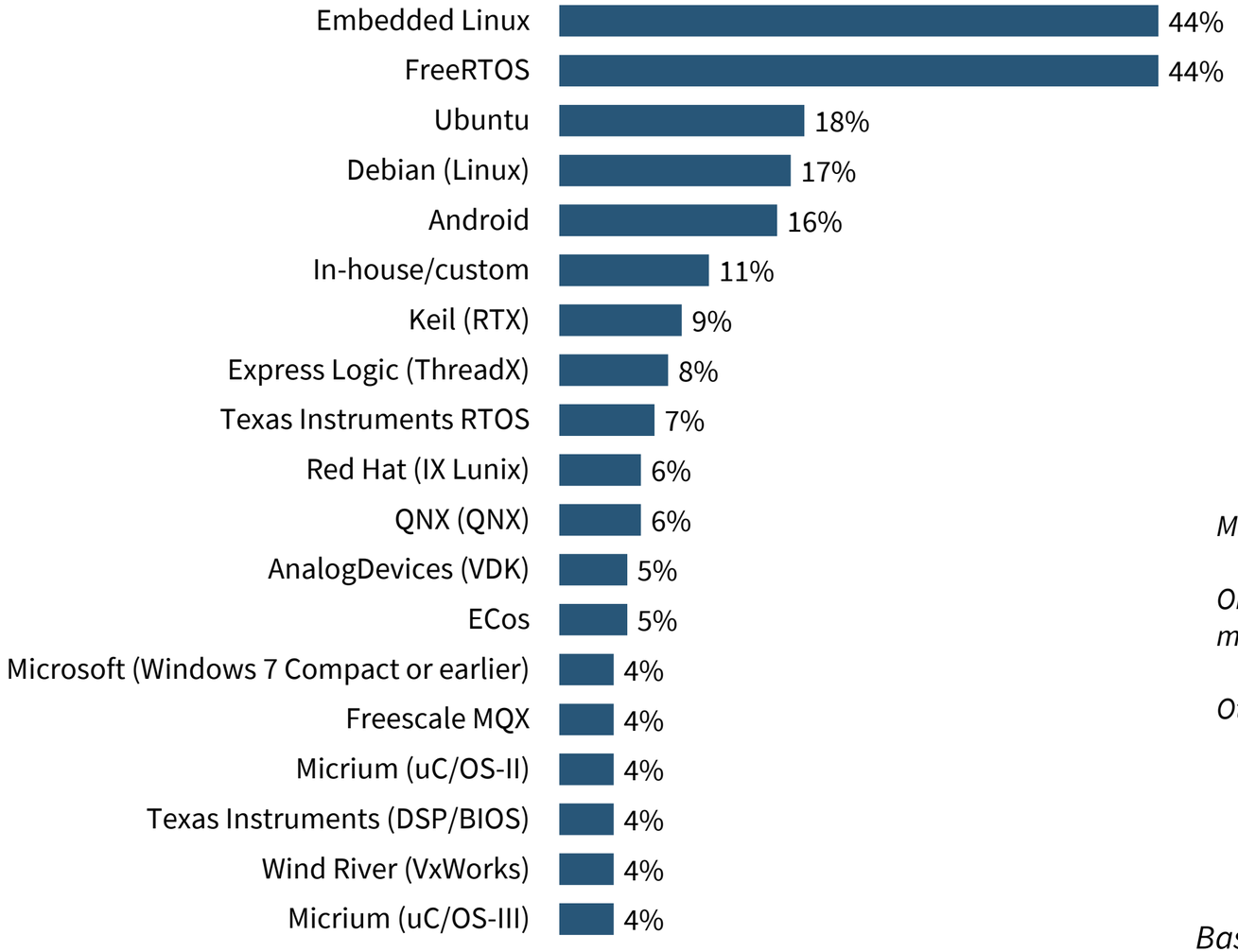
86% will use an OS for next embedded project



Total Respondents

Most popular embedded OSs – Embedded Linux, FreeRTOS and Ubuntu

Top 3 OSs are especially popular in APAC, while Embedded Linux is used more in the Americas



Multiple responses allowed

Only those with 4% or more total mentions shown

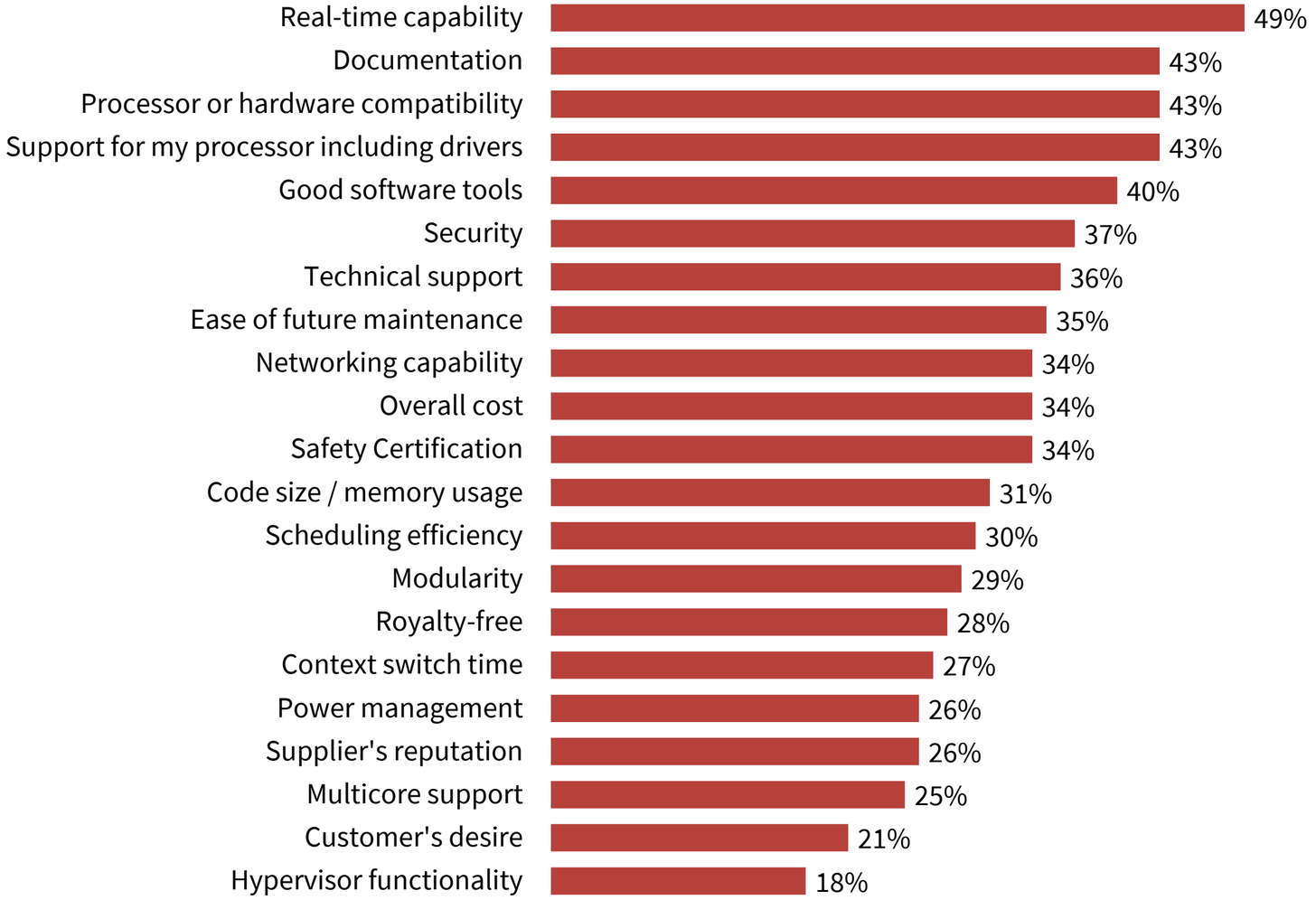
Other = 7%

Base = Those who <u>will use</u> an OS (566)

35. Please select the operating systems you are currently using or considering using in the next 12 months for a commercial product development project. ***(Only include non-RTOS operating systems that you embed into your projects.)***

Those using a commercial OS look for documentation, hardware compatibility and support to complement real-time capabilities

Large OEMs and APAC developers put particular emphasis on most commercial OS capabilities



'Very Important' Summary

Multiple responses allowed

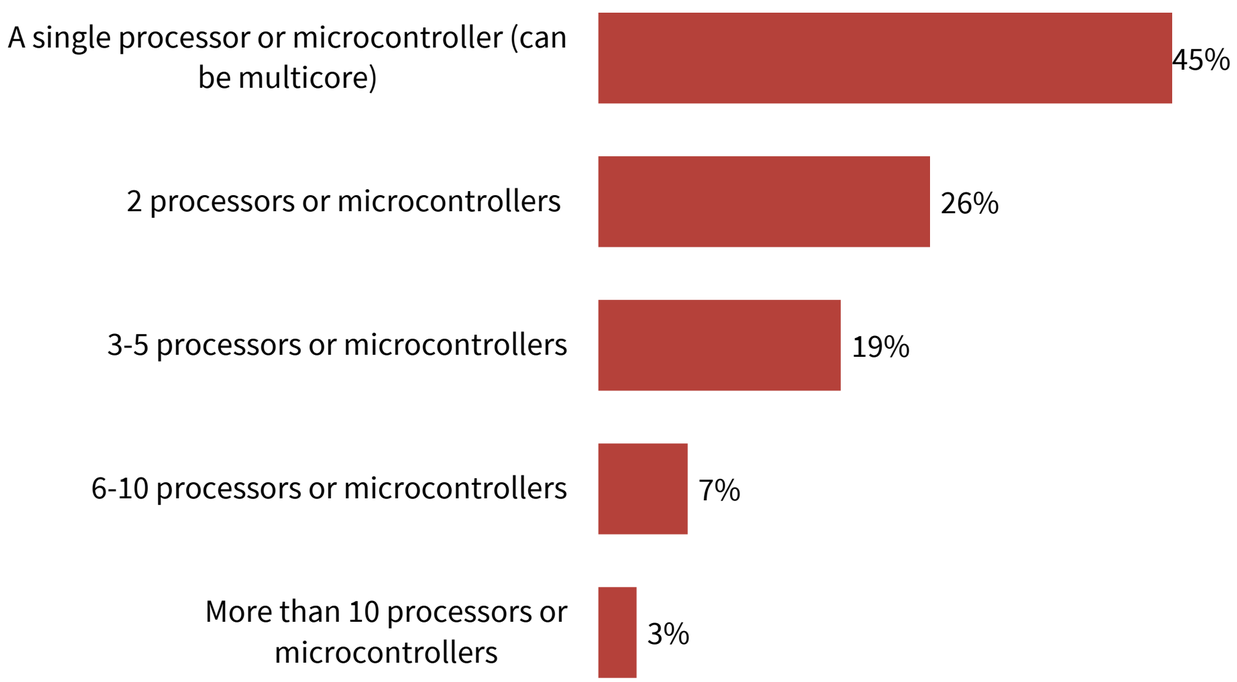
Base = Those using commercial OS (200)

Microprocessors / Microcontrollers / FPGAs

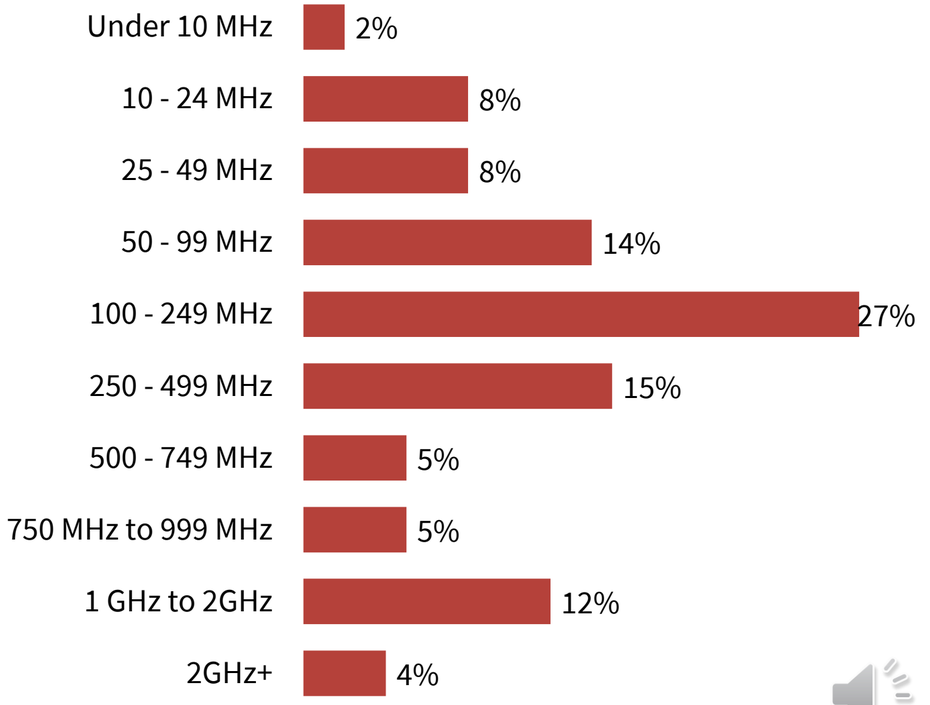
Most embedded projects use multiple processors

Multiprocessor designs are more common in the Americas. 32-bit processors continue to be the most prevalent.

MPUs/MCUs in Current Project



Main Processor Clock Rate

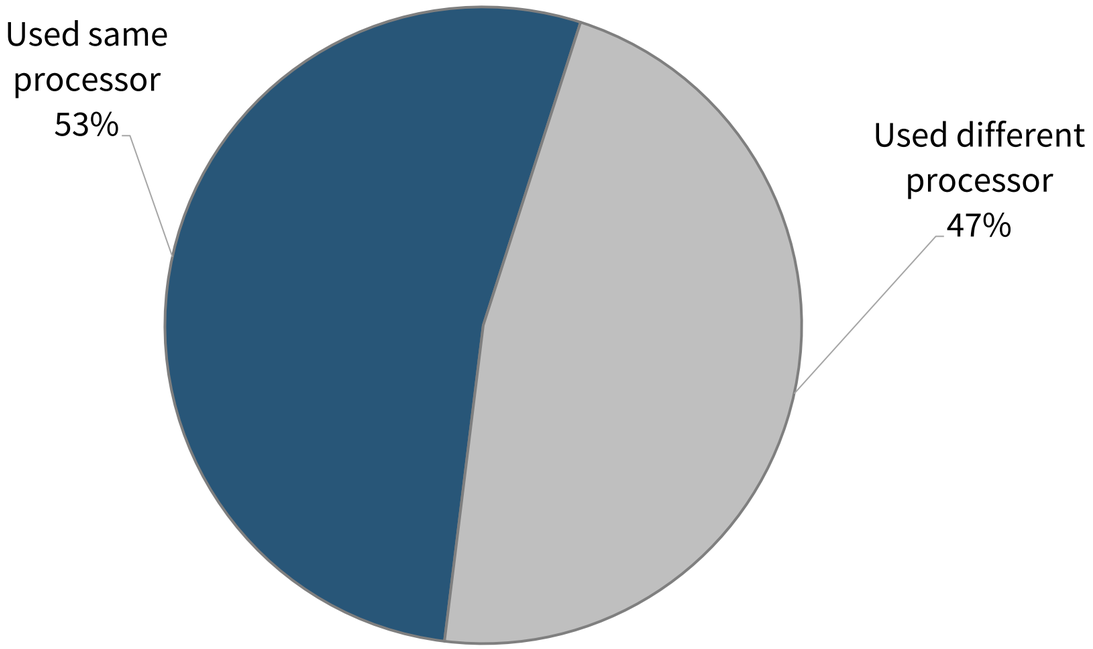


Total Respondents

Embedded designers prefer to MPUs/MCUs with which they have experience

Half choose same processor to ensure continuity, but others want access to more features and clearer roadmap

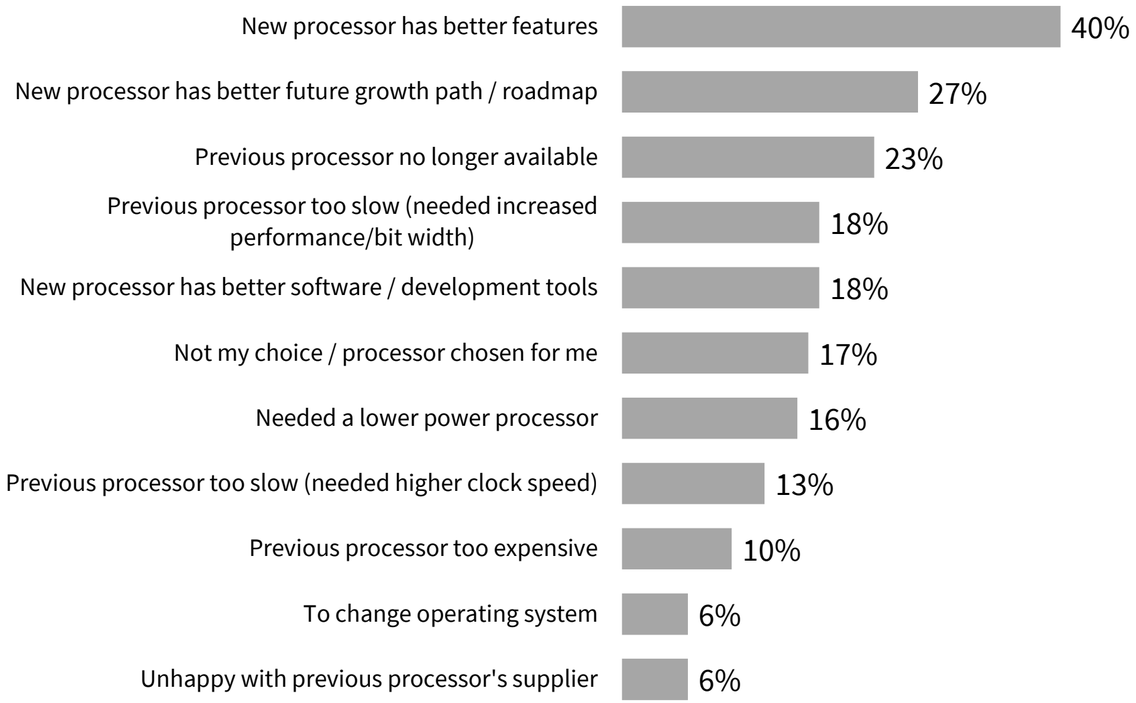
Use of Same Processor from Prior Project



Total Respondents

54% chose a processor from a different family, architecture or instruction set

Reason for Switching Processors



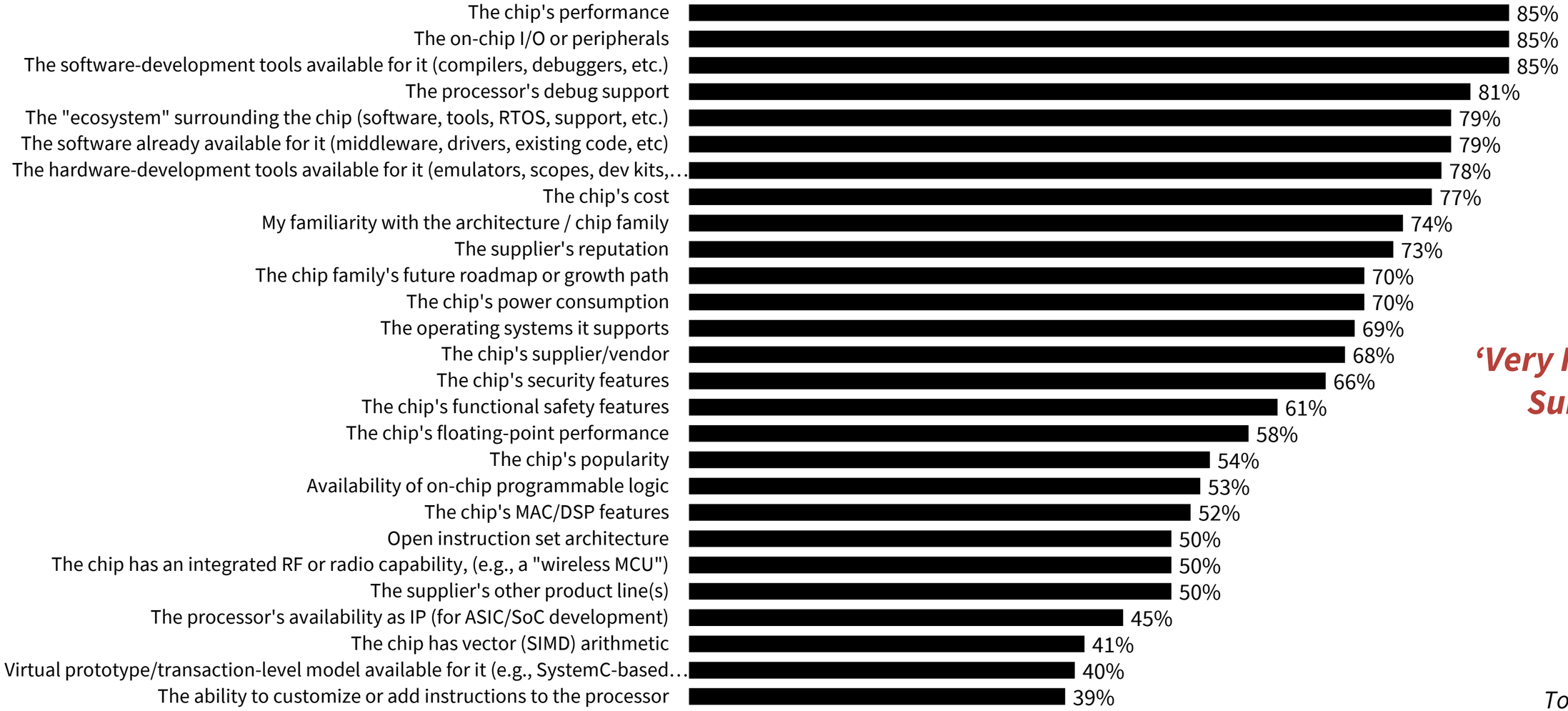
Multiple responses allowed

Other = 2%

Base = Those who did not use the same processor (305)

Processor selection involves weighing many interrelated factors

Performance, available peripherals, HW/SW tool environment, support ecosystem, and other issues are high on developer agendas

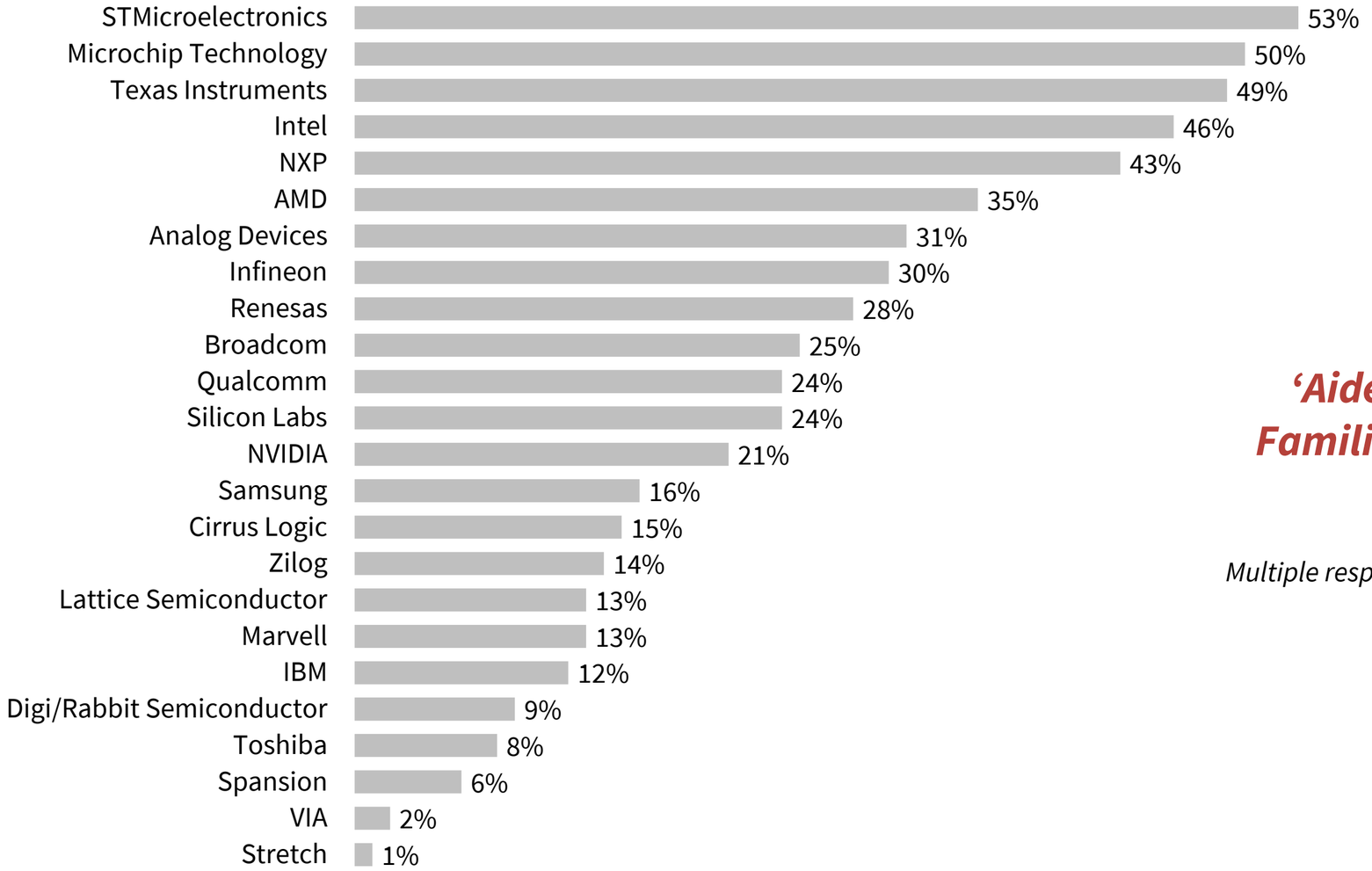


'Very Important' Summary

Total Respondents

Familiarity with MPU/MCU vendors

STMicro, Microchip, TI, Intel, and NXP are the most well-known processor vendors



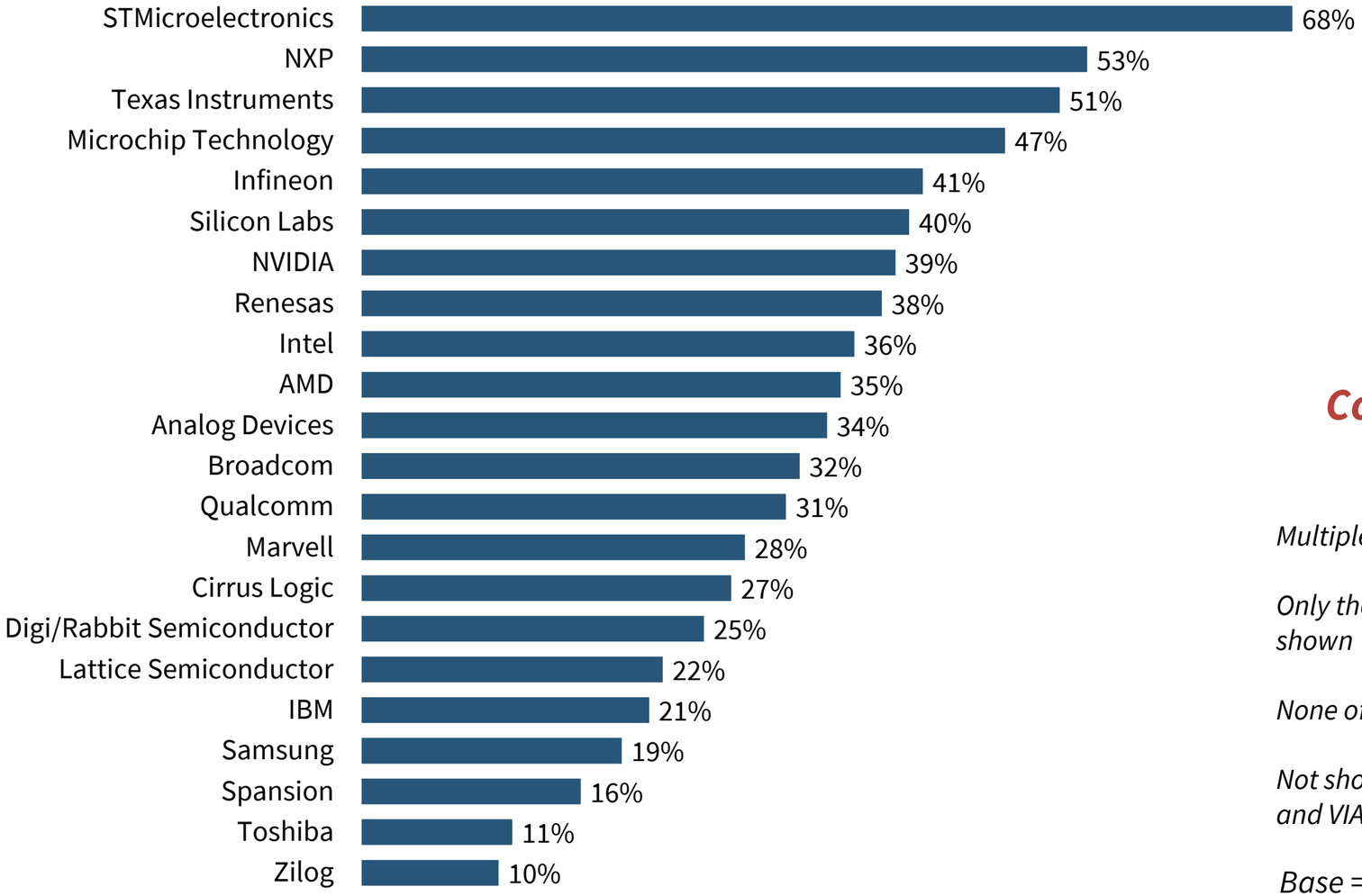
'Aided' Familiarity

Multiple responses allowed

Total Respondents

Future consideration of MPU/MCU vendors

STMicro, NXP, TI, and Microchip are the most efficient at converting familiarity into consideration for their processor solutions



'Aided' Consideration

Multiple responses allowed

Only those with 4% or more total mentions shown

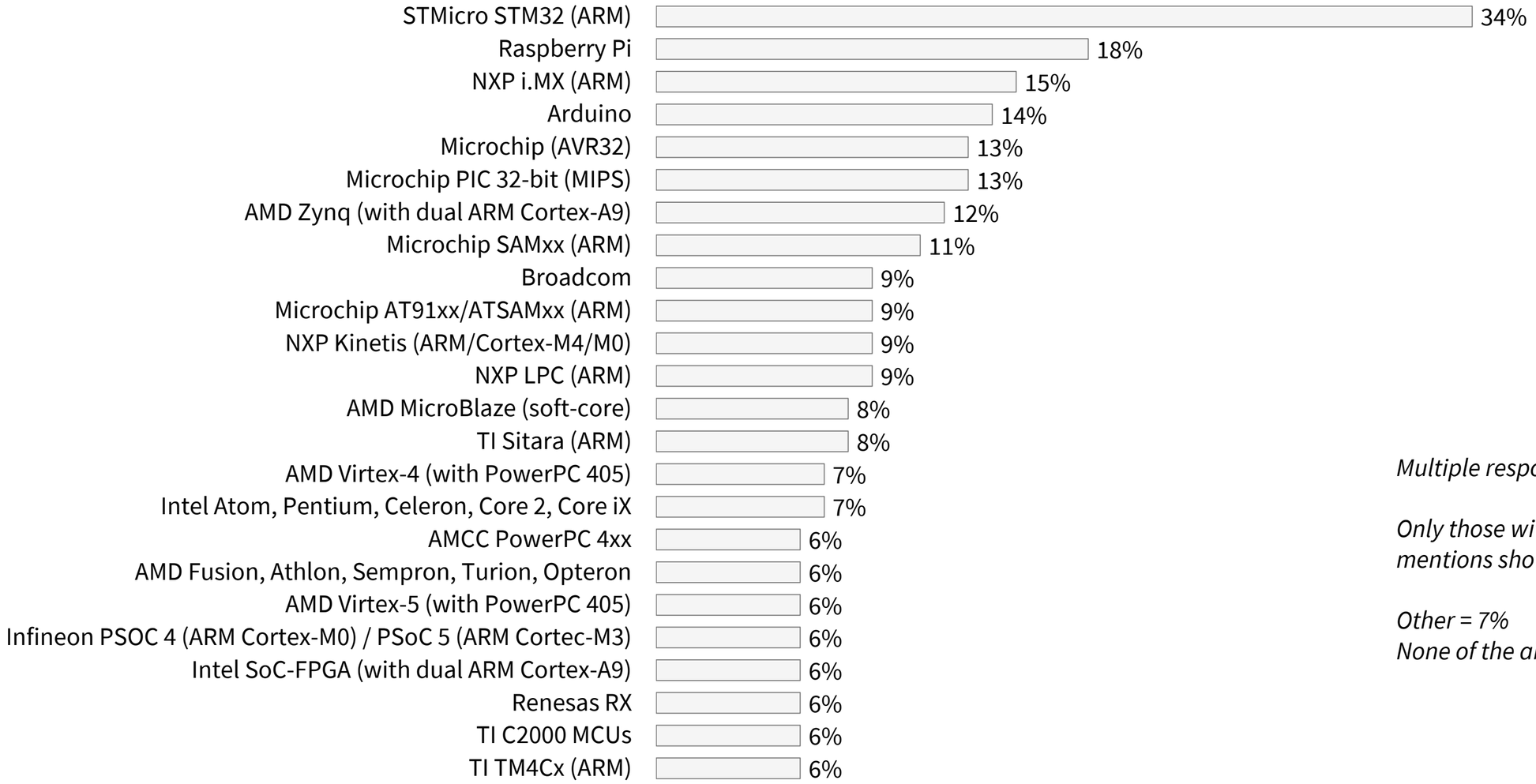
None of the above = 5%

Not shown due to small sample size: Stretch and VIA

Base = Those familiar with <u>each vendor</u>

Future consideration of 32-bit processor families

STMicro's STM32 is most widely considered, followed by Raspberry Pi, NXP's i.MX, Arduino and Microchip's AVR32



Multiple responses allowed

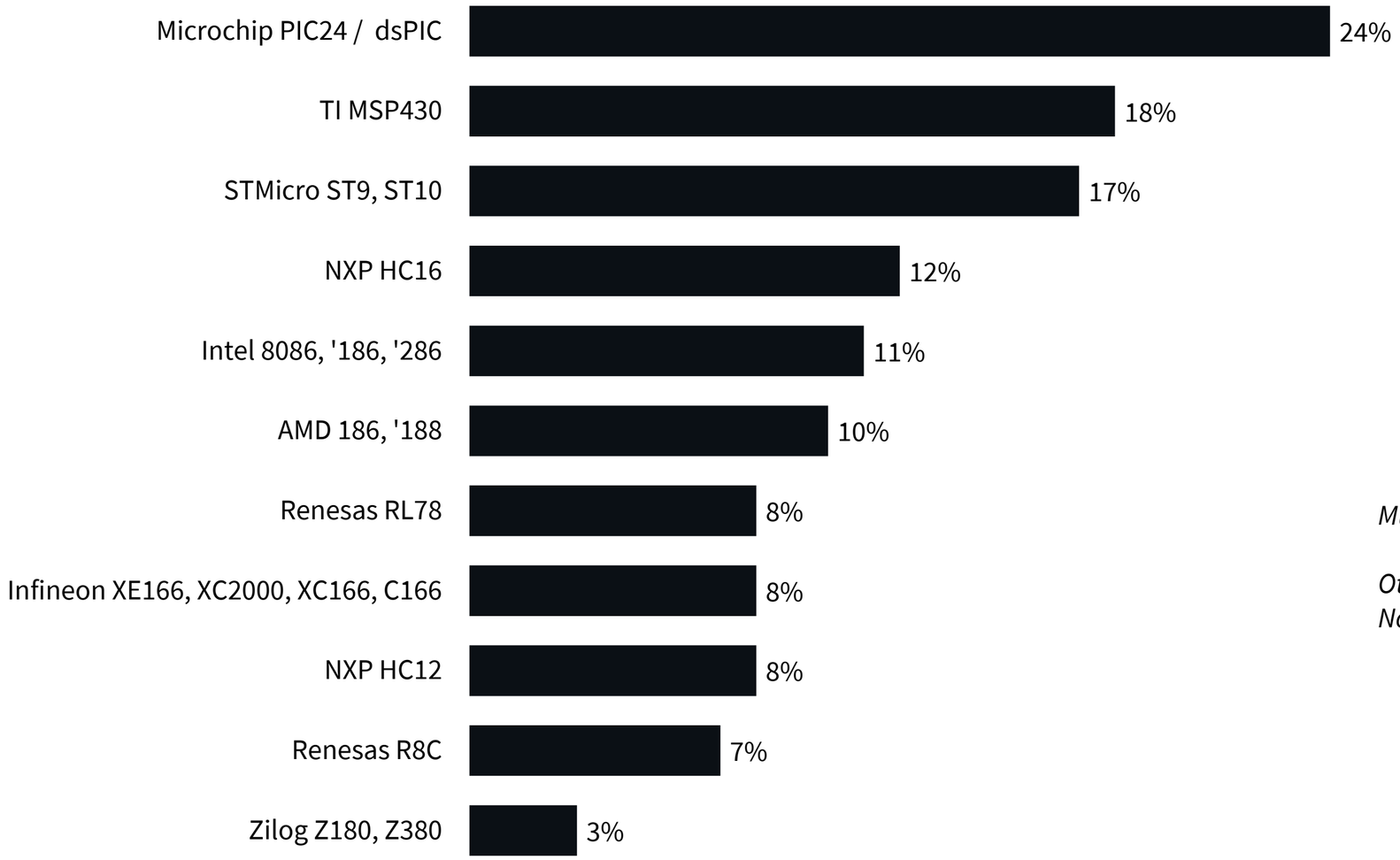
Only those with 6% or more total mentions shown

Other = 7%
None of the above = 8%

Total Respondents

Future consideration of 16-bit processor families

Microchip’s PIC24 / dsPIC, TI’s MPS430 and STMicro’s ST9 and ST10 are the 16-bit processors under consideration



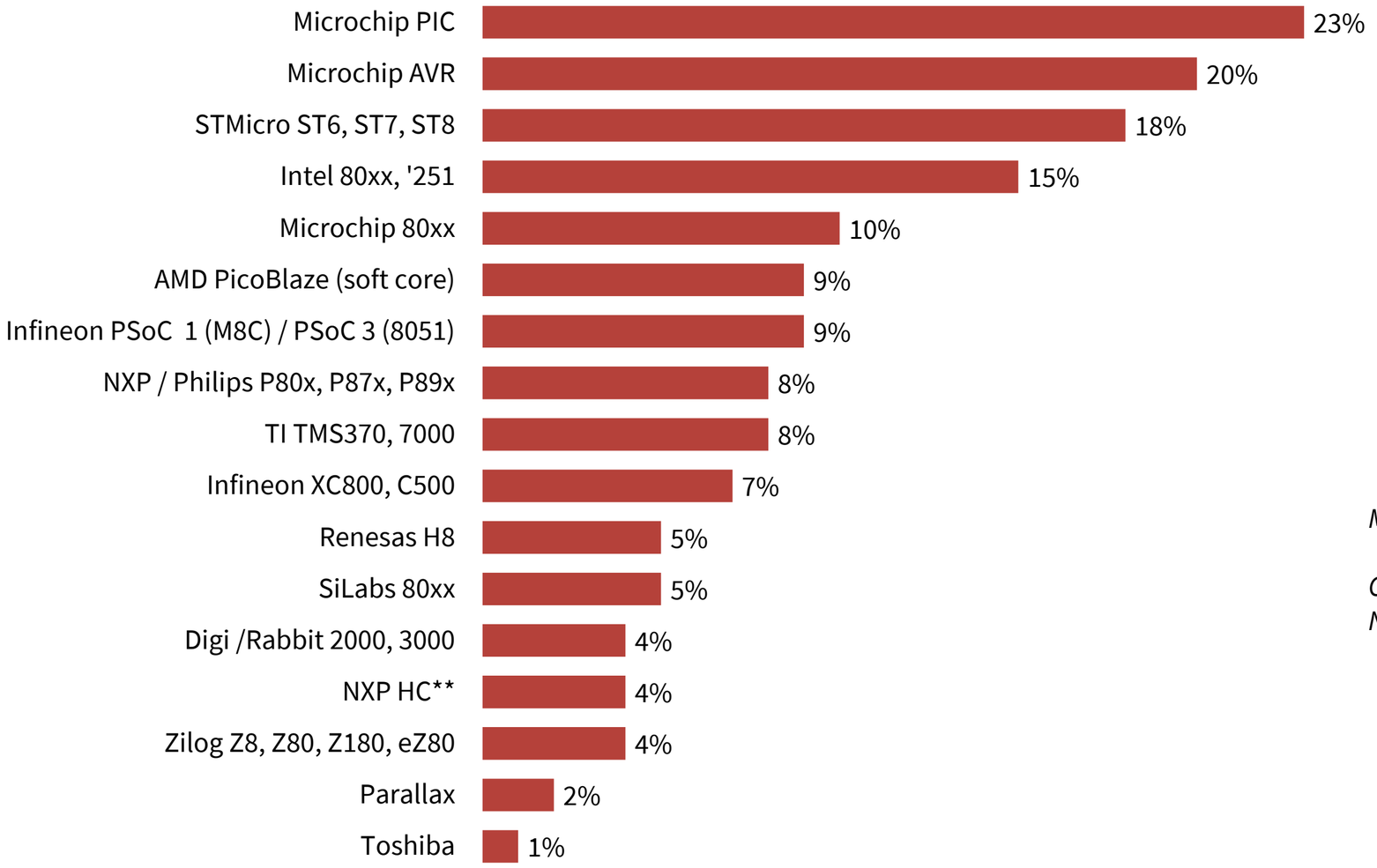
Multiple responses allowed

Other = 2%
None of the above = 36%

Total Respondents

Future consideration of 8-bit processor families

Microchip's PIC and AVR, STMicro's ST6, ST7 and ST8 and Intel's 80xx 8-bit processors are the most popular



Multiple responses allowed

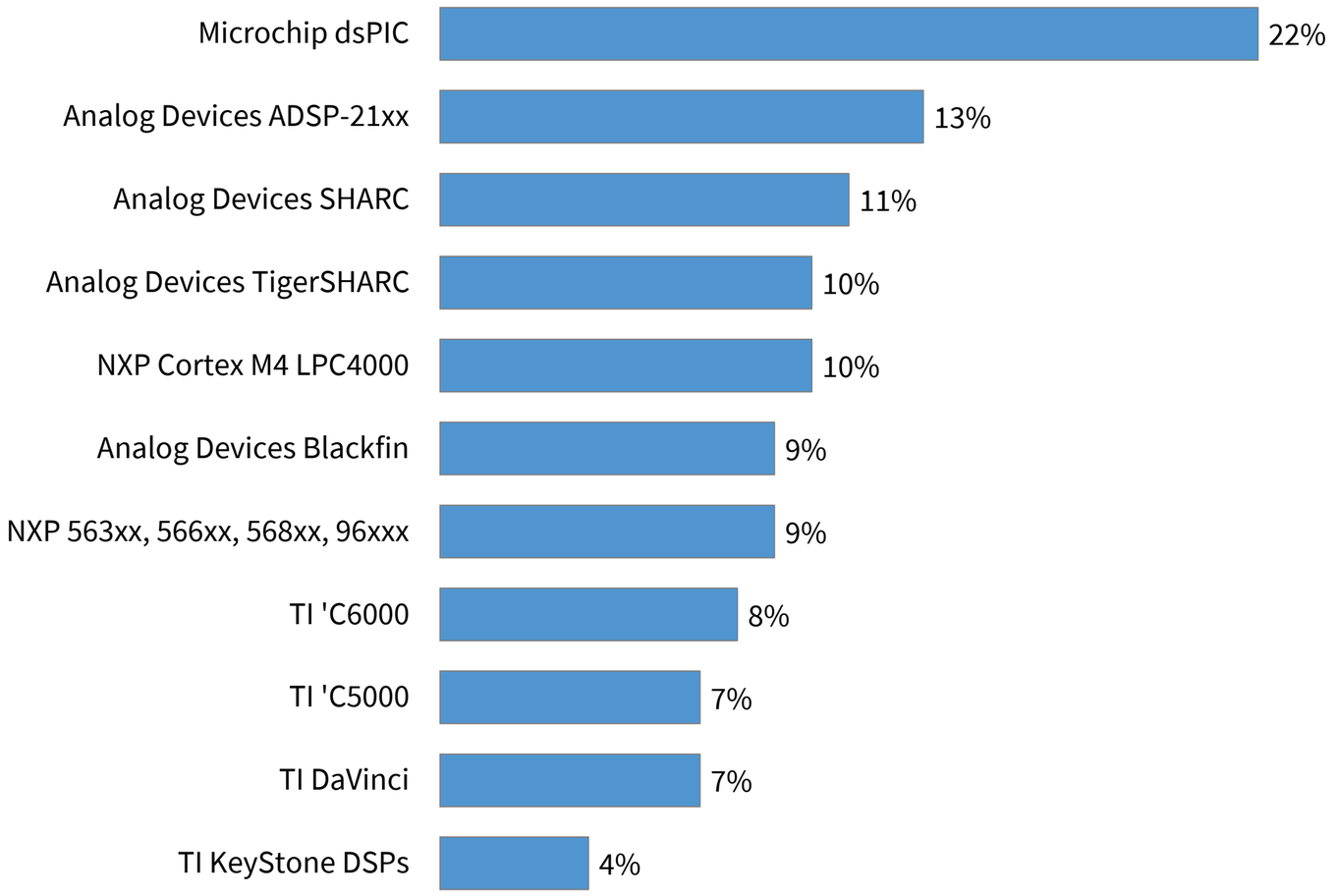
Other = 5%
None of the above = 31%

Total Respondents

Future consideration of DSP families

Microchip's dsPIC and ADI's ADSP-21xx, SHARC and TigerSHARC are the leaders in this category

44% would not consider a DSP chip



Multiple responses allowed

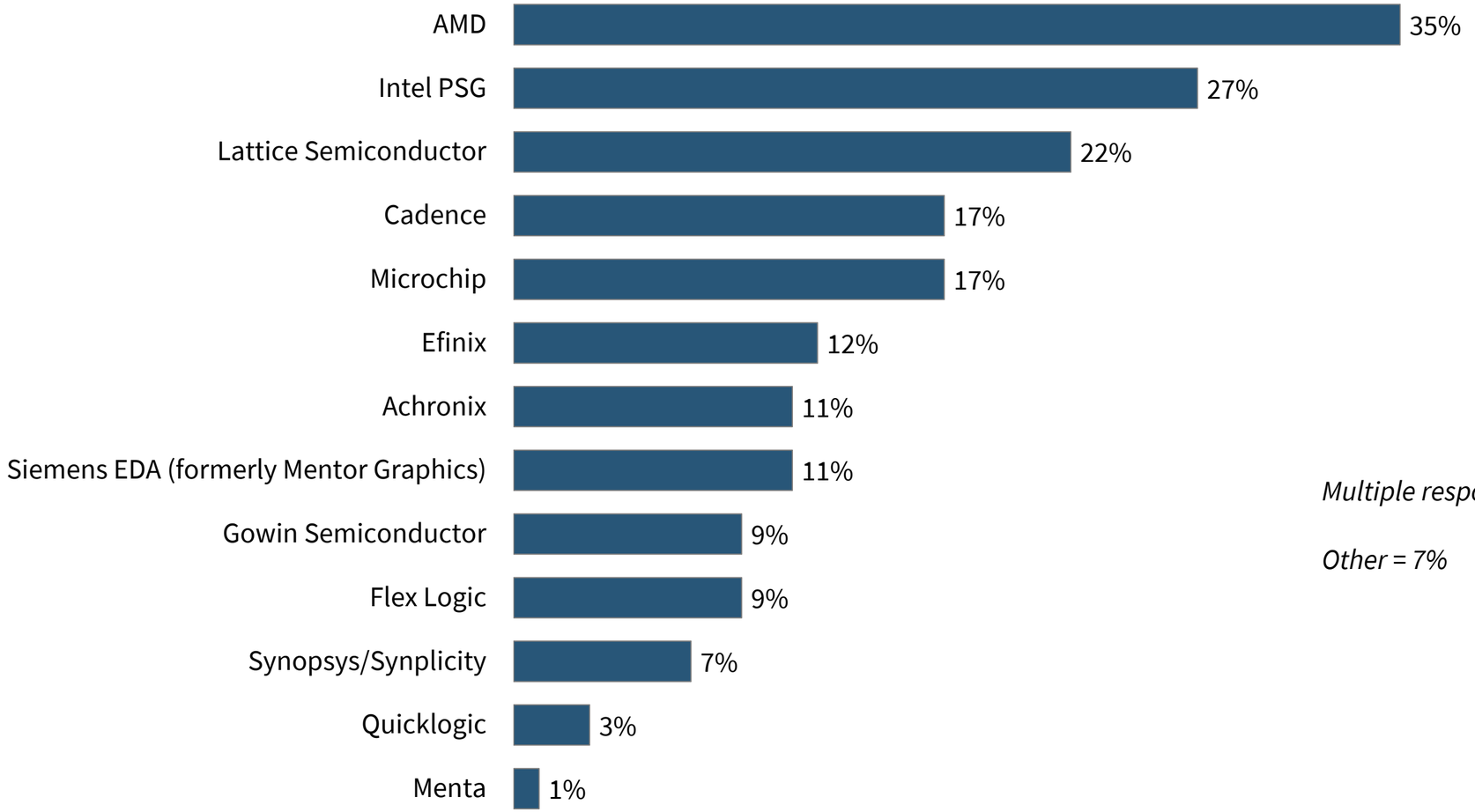
Other = 2%
None of the above = 44%

Total Respondents

Future consideration of FPGAs

AMD and Intel PSG are the most widely used vendors in the programmable logic space

37% have incorporated FPGA chips in current project



Multiple responses allowed

Other = 7%

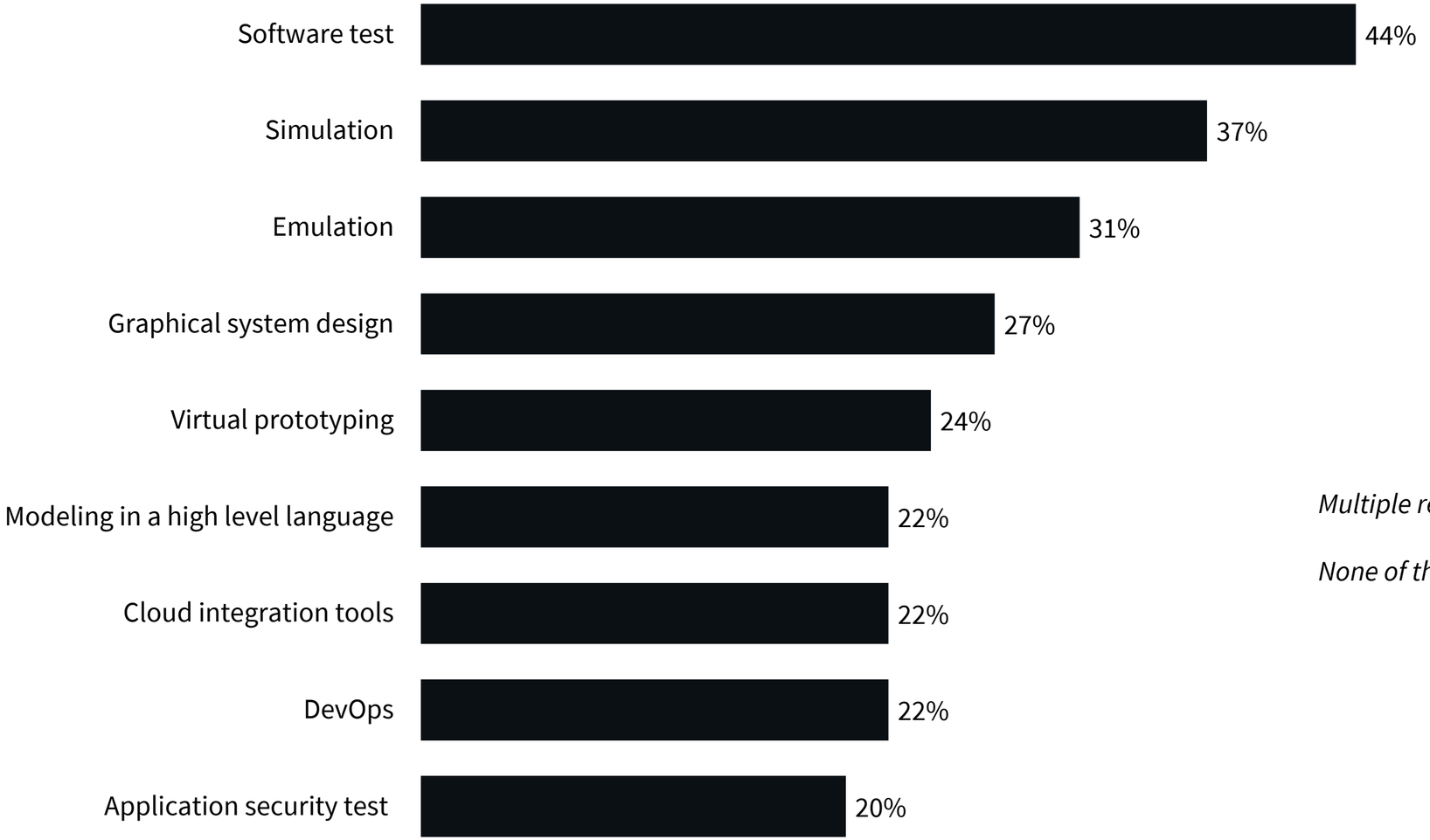
Total Respondents

56. Does your current embedded project incorporate an FPGA chip?
57. Which of the following FPGA vendors and FPGA tool vendors do your current embedded projects use or consider using in the next 12 months?

Design Tools

Software testing, simulation and emulation will grow in importance

EMEA and APAC teams are especially keen on SW test, simulation and emulation, and GUI system design



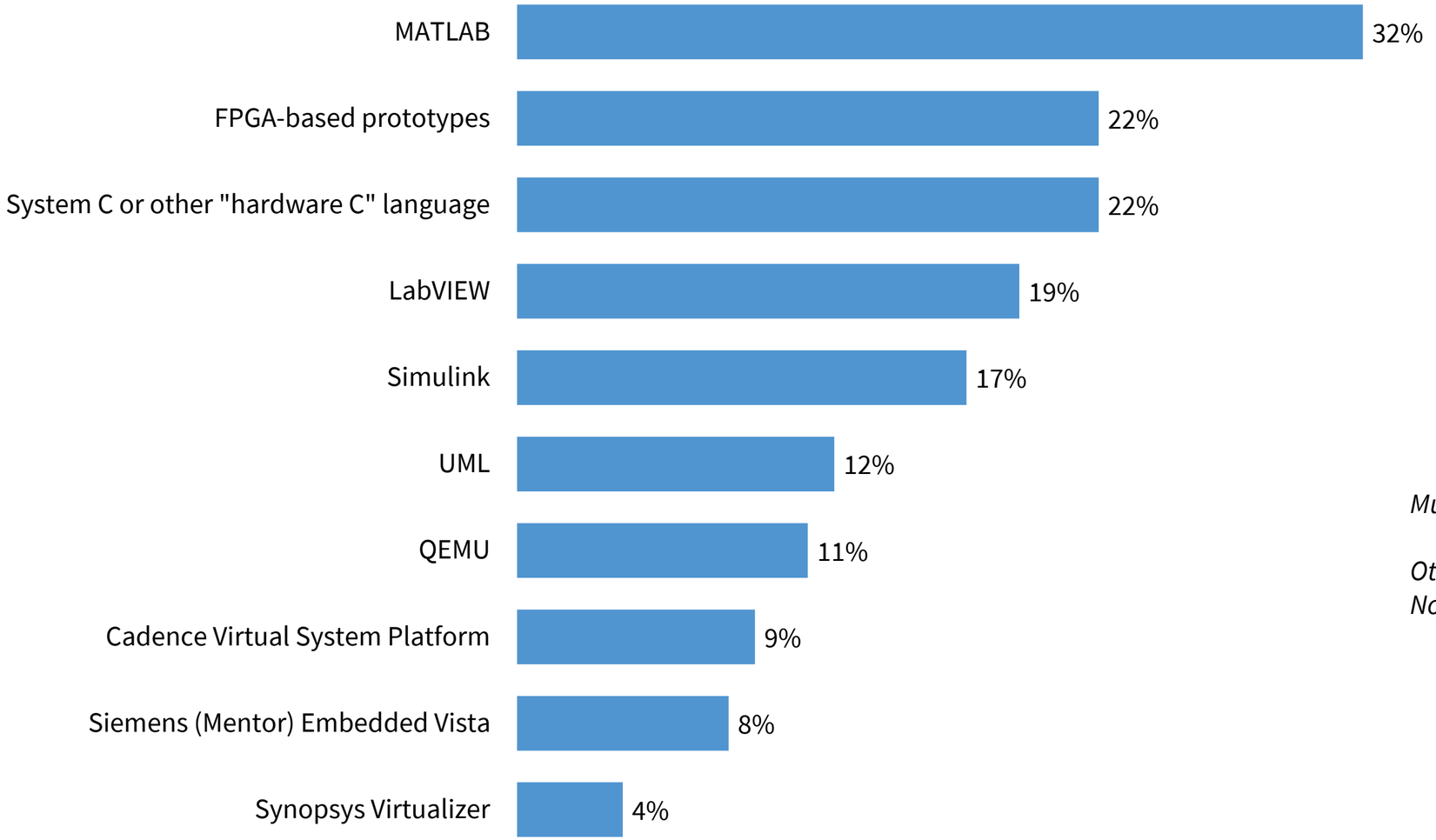
Multiple responses allowed

None of the above = 7%

Total Respondents

MATLAB is the most widely used system-level design tool

Also commonly used are FPGA prototypes (in the Americas) and System C language (in APAC and EMEA)



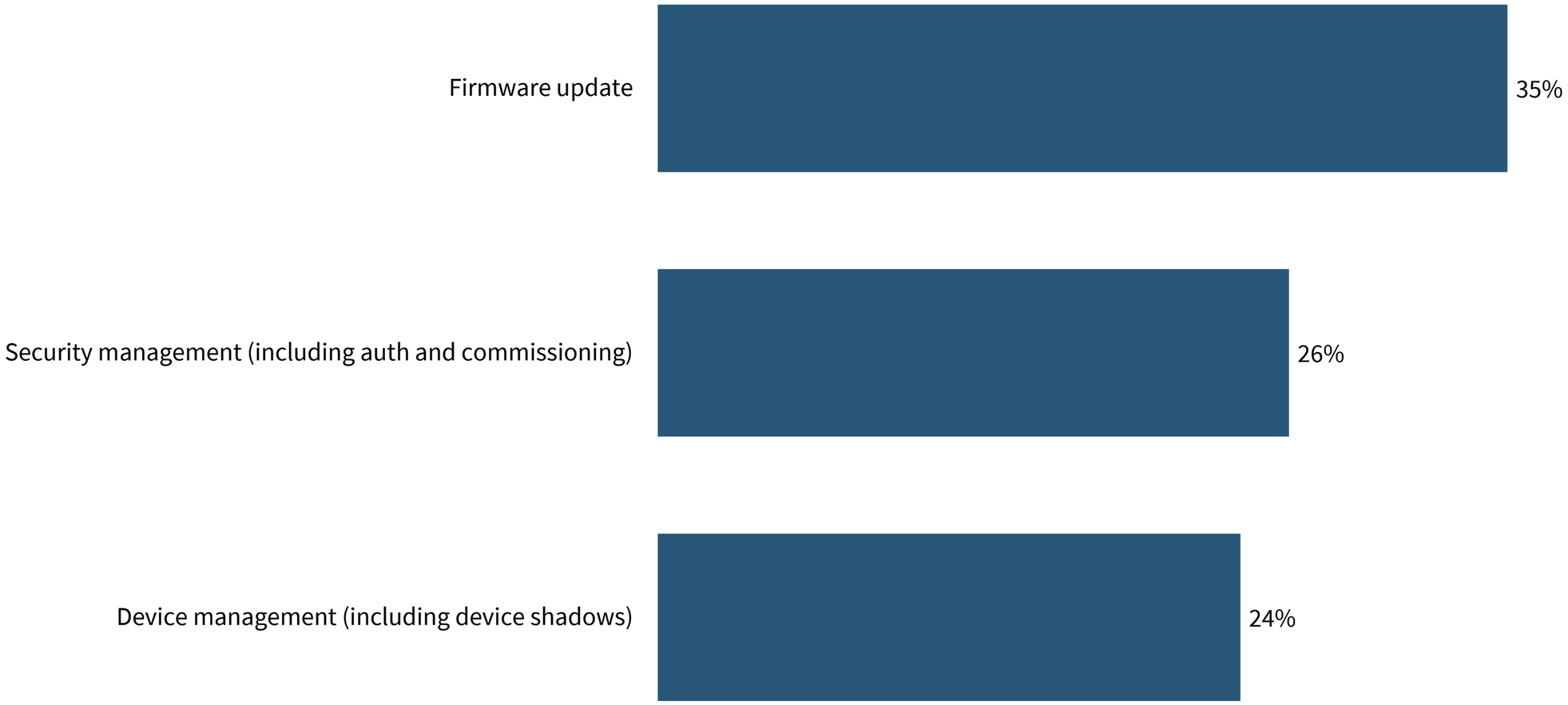
Multiple responses allowed

Other = 2%
None of the above = 26%

Total Respondents

Cloud integration tools are used for firmware updates and security management

More popular in the Americas, security and device management tools are more apt to be used in “new” designs



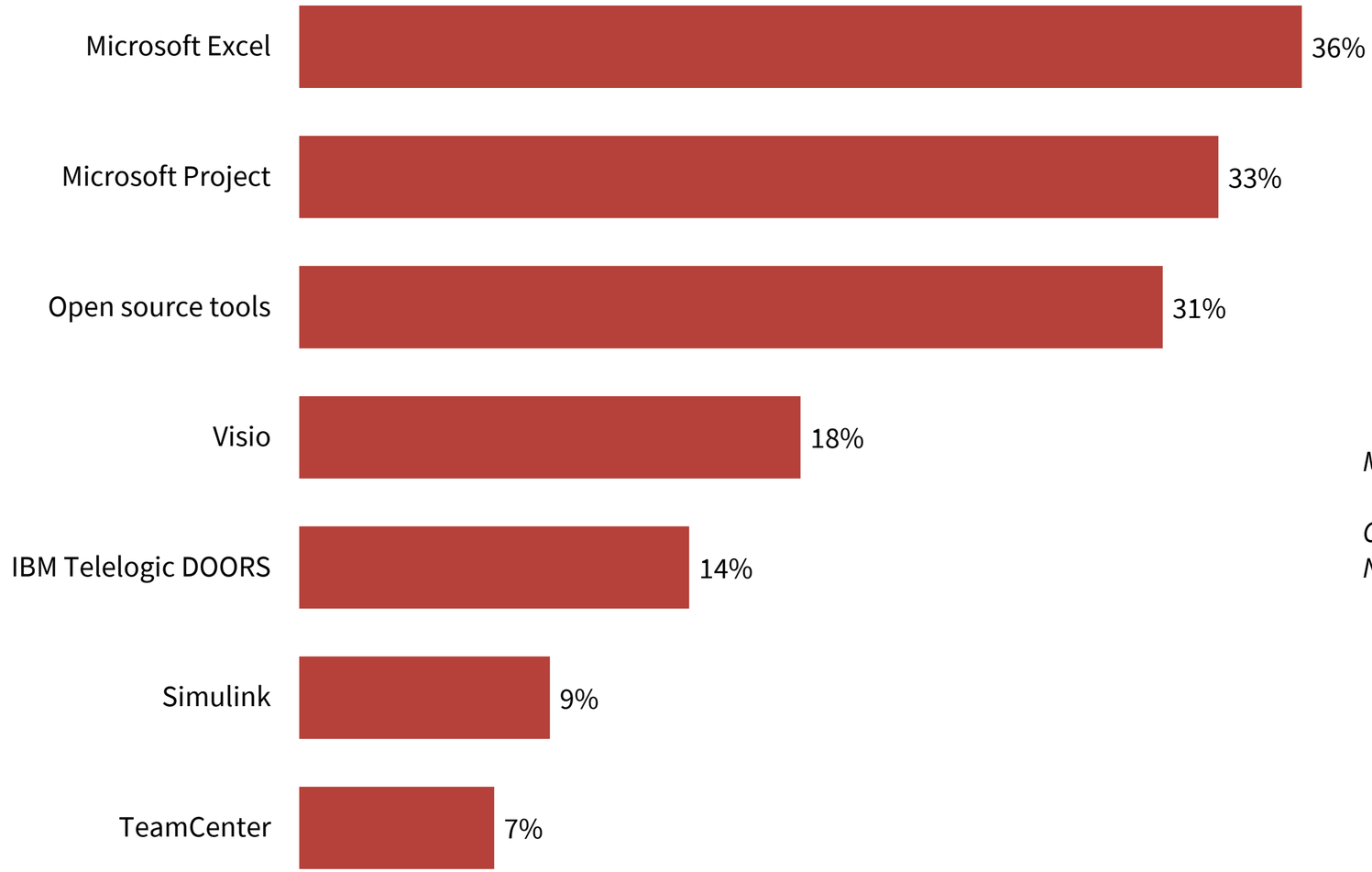
Multiple responses allowed

Other = 1%
None / Don’t use cloud integration tools = 43%

Total Respondents

Most used project management platforms: MS Project and Excel

Managers more apt to depend on MS Project, IBM Telelogic DOORS, TeamCenter or open-source packages



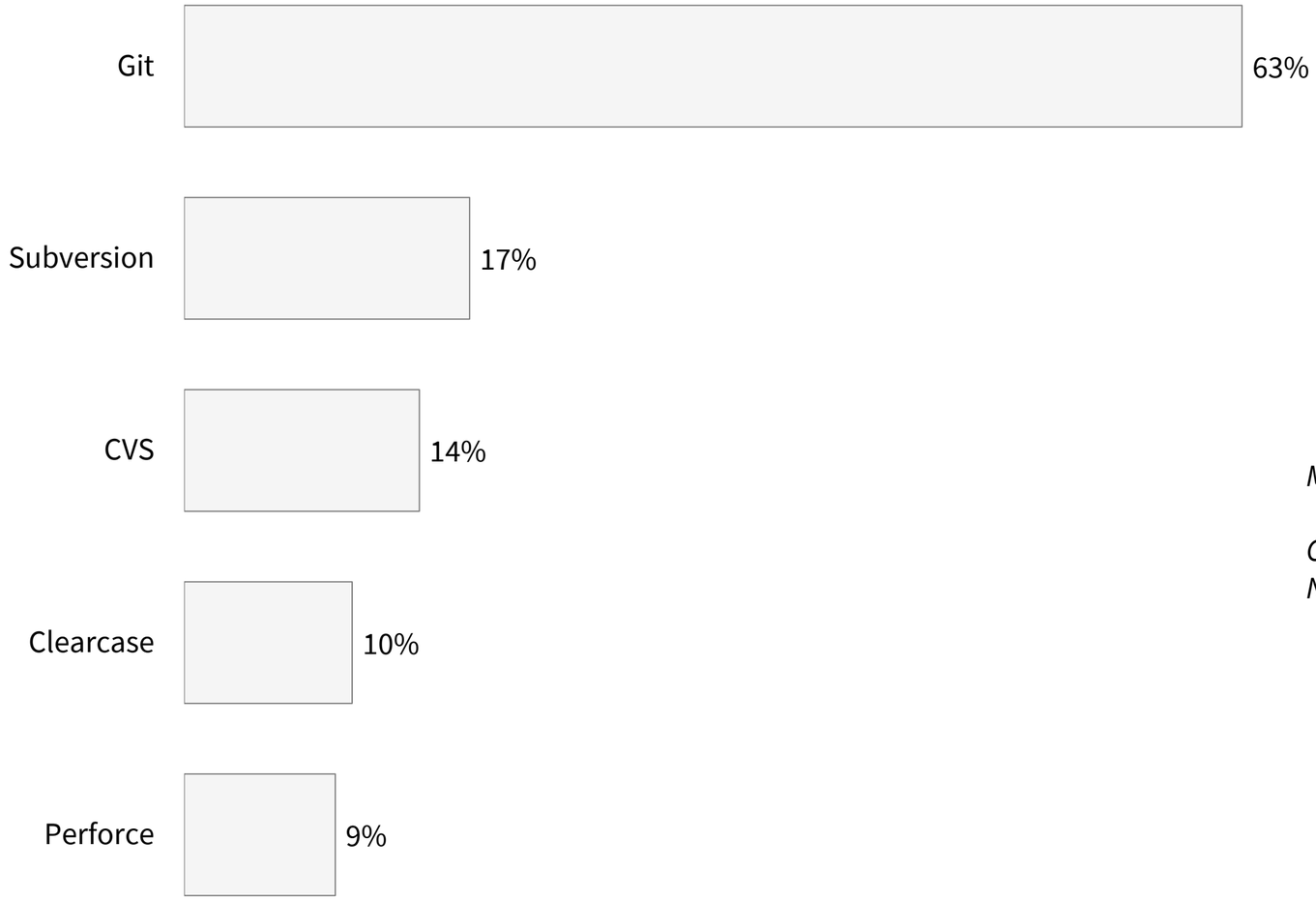
Multiple responses allowed

Other = 6%
None of the above = 19%

Total Respondents

Git is the most widely used version control software

Git and Subversion are especially popular in EMEA



Multiple responses allowed

Other = 3%
None of the above = 14%

Total Respondents

Information, Training & Continuing Education

Most utilized methods for self-education on embedded development trends – online training, plus vendor white papers and professional/technical journals

Early career engineers are more apt than older peers to also consider training provided from professional associations and private companies

Most effective ways to maintain professional skills

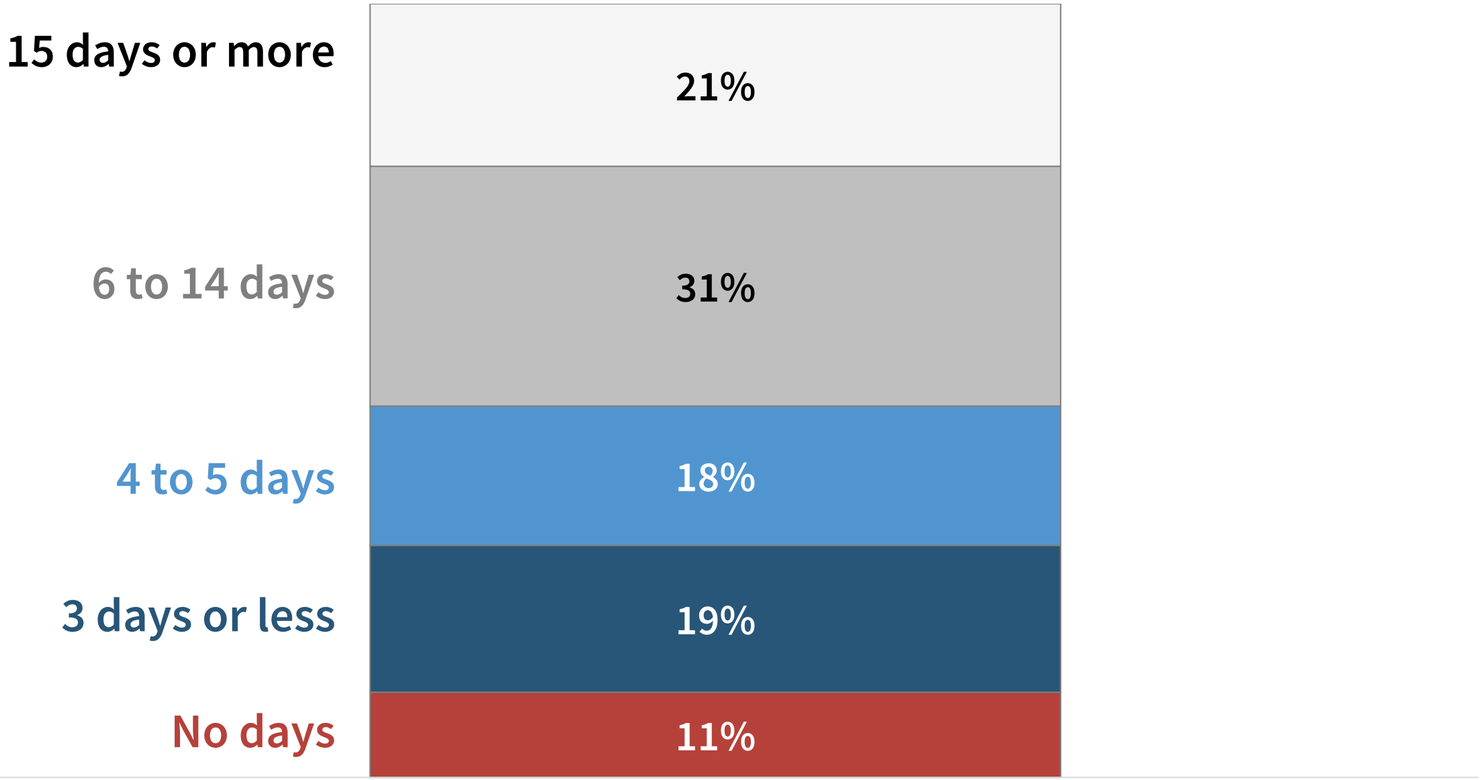
Total Respondents

68. What are the four most effective ways that you systematically or formally maintain, educate and advance your professional skills?

Embedded engineers devote two full work weeks to formal training

APAC and earlier career engineers spend 20% more time in training than do their colleagues

Mean = 10.2 days per year



Days per year spent on formal career-based training

Select up to FOUR

Other = 1%
I do not have a systematic/formal method of advancing my professional skills = 4%

Total Respondents

Observations

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The Embedded Development Environment

OBSERVATIONS

- **Most embedded projects involve incremental upgrades to existing designs (such as adding software features or new MPUs/MCUs)**
  - Most projects are developed for industrial automation and instrumentation, IoT, communications, and automotive
  - Current embedded development devotes considerable attention to performance, connectivity, power efficiency and signal processing
- **Embedded development teams (containing, on average, 20 engineers) have burgeoning workloads**
  - Teams typically tackled over 4 projects in the past year, with two in the development pipeline at any point in time
  - Embedded projects take 8 months on average to complete, with SW design requiring 50% more development time than hardware
  - Reuse of software code, hardware and IP is common, as is the use of development boards (particularly Raspberry PI and Arduino)
- **Most pressing embedded design challenges - meeting performance specs, choosing the right processor and test/debugging, along with safety, security and power management**
  - Over one-third of embedded designs incorporate wireless capabilities
  - IP theft, product tampering, and cloning are primary security issues, especially for larger OEMs
  - Nearly one-third of embedded design is devoted wholly or partially to IoT applications, most for sensor-driven, industrial or mobile communications
  - Embedded AI and machine learning attract considerable attention, followed by embedded vision and speech capabilities

Operating Systems

OBSERVATIONS

- **Most embedded projects will increasingly utilize an operating system**
  - Four in use either commercial OS or open-source OS distributed commercially, but nearly 30% of those now using commercial OS are considering open-source alternatives
- **Leading OS selection criteria – processor support, tools, and overall cost**
  - Also high on the agenda: security, design customizability and flexibility, and ease of use
- **Most popular embedded OSs – Embedded Linux, FreeRTOS, Ubuntu, Debian and Android**
- **Half use or plan to use embedded hypervisors**
  - Key reasons: support for safety and security, and separation of multiple real-time and legacy applications as well as “guest” operating systems

Microprocessors / Microcontrollers / FPGAs

OBSERVATIONS

- **Most embedded projects use multiple processors or multicore solutions**
  - Typical embedded designs include 2+ MPUs/MCUs (particularly in the Americas), although clock rates are faster among Asian developers.
  - 32-bit processors continue to be the most prevalent, and 39% upgraded to larger processors in the past year
- **Half of the embedded designs contain different MPUs/MCUs than were used previously in order to obtain access to more features and a clear roadmap for the future**
  - Among those using different processors, half chose from within the same family or architecture, while another half chose a different architecture or family
  - Among the important processor selection criteria are performance, available peripherals, HW/SW tool environment, and support ecosystem
- **STMicro, Microchip, TI, Intel, and NXP are the most well-known processor vendors**
  - STMicro's STM32 is the most widely considered 32-bit processor along with Raspberry Pi, NXP's i.MX, Arduino and Microchip's AVR32, while Microchip's PIC24 / dsPIC, TI's MPS430 and STMicro's ST9 and ST10 are the 16-bit processors most under consideration, and Microchip's PIC and AVR, STMicro's ST6, ST7 and ST8 and Intel's 80xx 8-bit processors are the most popular
  - Widely considered DSPs include Microchip's dsPIC and ADI's ADSP-21xx, SHARC and TigerSHARC
  - AMD and Intel PSG are the best-known and used vendors in the programmable logic space

Design Tools

OBSERVATIONS

- **Software testing, simulation and emulation will grow in importance as embedded design techniques**
  - EMEA and APAC teams are especially likely to utilize these approaches
- **Embedded designers utilize a wide variety of SW/HW design tools – including compilers, debuggers, oscilloscopes, logic analyzers, design environments, and SW libraries**
  - EMEA embedded development teams are more likely than are peers elsewhere to use these tools
- **MATLAB is the most widely used system-level design tool**
  - Also commonly used are FPGA prototypes (in the Americas) and System C language (in APAC and EMEA)
- **Cloud integration tools are used for firmware updates and security management**
  - More popular in the Americas, security and device management tools are more apt to be used in “new” designs
- **Most used project management platforms: MS Excel and MS Project**
- **Git is the most widely used version control software solution**

Information, Training & Continuing Education

OBSERVATIONS

- **Vendor websites (SW and HW), white papers, standards-related publications, and webinars/webcasts join search engines as the most widely used information sources**
  - Other than social media platforms, early career embedded developers trail their more experienced colleagues in their use of nearly all content delivery vehicles
- **Embedded developers eagerly consume vendor-supplied training resources**
  - The typical embedded engineer devotes roughly two work weeks per year to formal training
  - Early career engineers also look to professional associations and private 3rd parties for additional training
  - Popular industry events showcasing embedded development include Embedded Linux Conference (ELC), Embedded Systems Conference, CES and Embedded World
- **In addition to online training, widely utilized methods for self-education on trends in embedded development include vendor white papers and professional/technical journals**
  - Roughly one hour a day on average is allocated to reading technical publications

Questions and Answers

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Thank You

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