

The Current State of Embedded Development

MAY 2023

Methodology

Online survey

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

- 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%)

embedded

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KLI	The second	I'S MAN	APAC	24%
JYN			India	8
i sont s			Taiwan	7
EMEA	23%		🔪 China	4
Germany	3		Other APAC	5
Italy	3		and the second s	
UK	3			
France	2			
Other EMEA	12			
				- All and a second

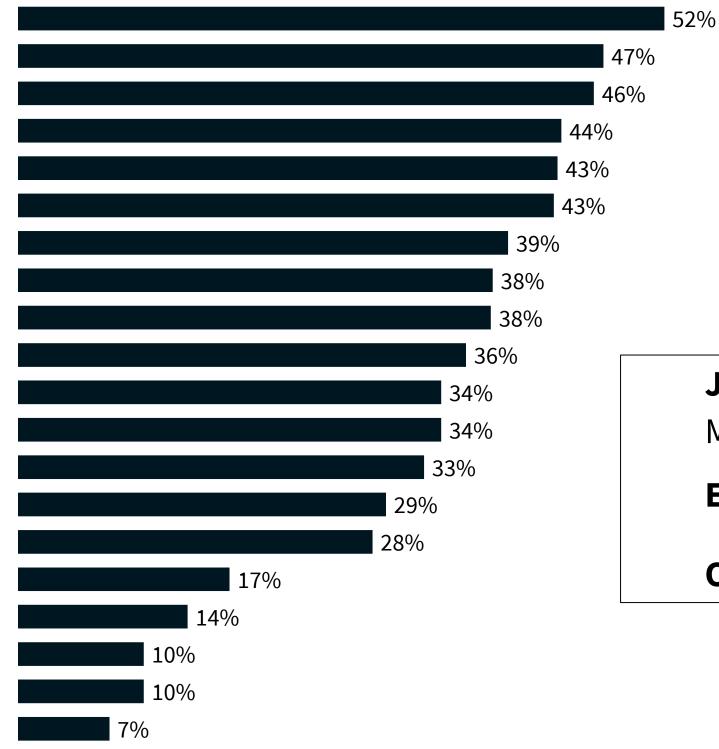
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Total Respondents

Respondent Characteristics

Job responsibilities, experience and organization size

Writing firmware/software for embedded systems Hardware/software integration Debugging firmware/software Firmware/software design or analysis Firmware/software testing System design Prototype testing Designing hardware for embedded systems Hardware/software co-design Debugging hardware Device programming Project management Architecture selection/specification Hardware/software co-verification Board layout/design Connected device design Security design SoC (system-on-chip) design DevOps Data science





73. My job responsibilities include:

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

Experience: 18.9 years

Organization size: 3,288 employees



Total Respondents

The Embedded Development Environment

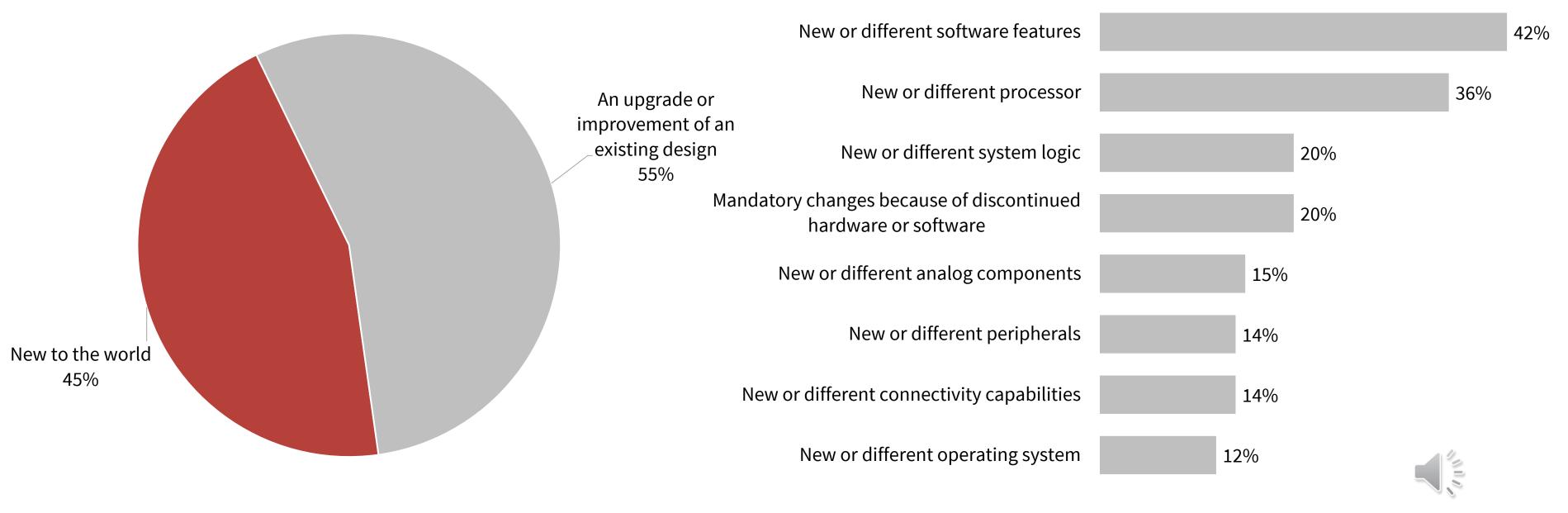




Most embedded projects involve incremental upgrades to existing designs

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

Current Embedded Project Is...



Total Respondents



- 1. My current embedded project is:
- 2. Which two improvements were the main reasons for the upgrade?

Improvements for Upgrade

Base = Those upgrading existing design (362)

ASPENCORE 5

Embedded projects target a wide range of applications

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

-	
Industrial control/automation	
Internet of Things (IoT)	
Communications, networking and wireless	
Automotive	
Electronic instruments	
AI or Embedded AI	
Consumer electronics: home appliances/systems	1
Medical/health	13%
Computers and peripherals	13%
Consumer electronics: games and entertainment	12%
Consumer electronics: handheld devices	12%
Military/aerospace	12%
Security	9%
Power generation and utilities	8%
Audio	7%
Video/imaging	6%
Transportation	5%
M2M	5%
Government/municipal	5%



6. For what types of applications are your embedded projects developed?

		29%
	24%	
21%		
19%		
18%		
17%		
17%		

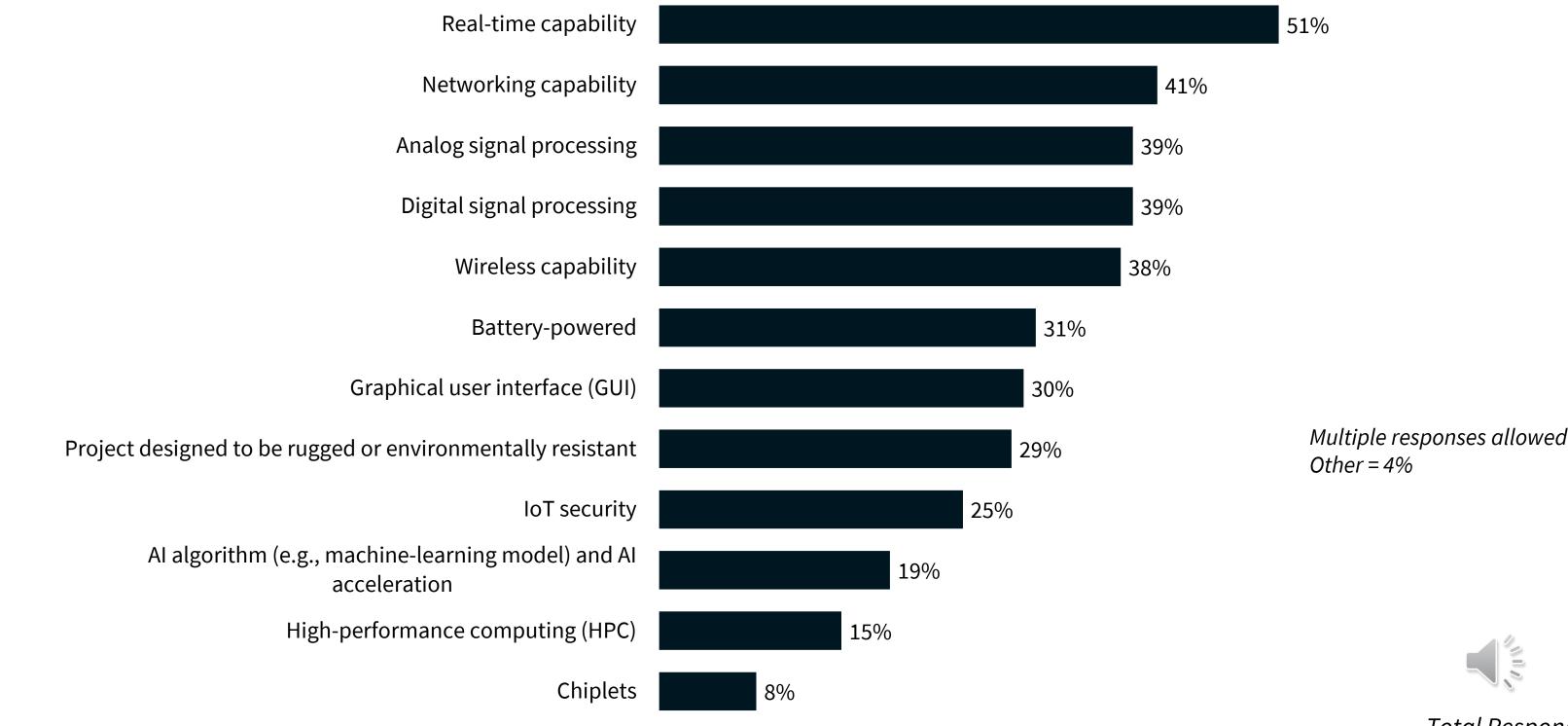
Multiple responses allowed



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



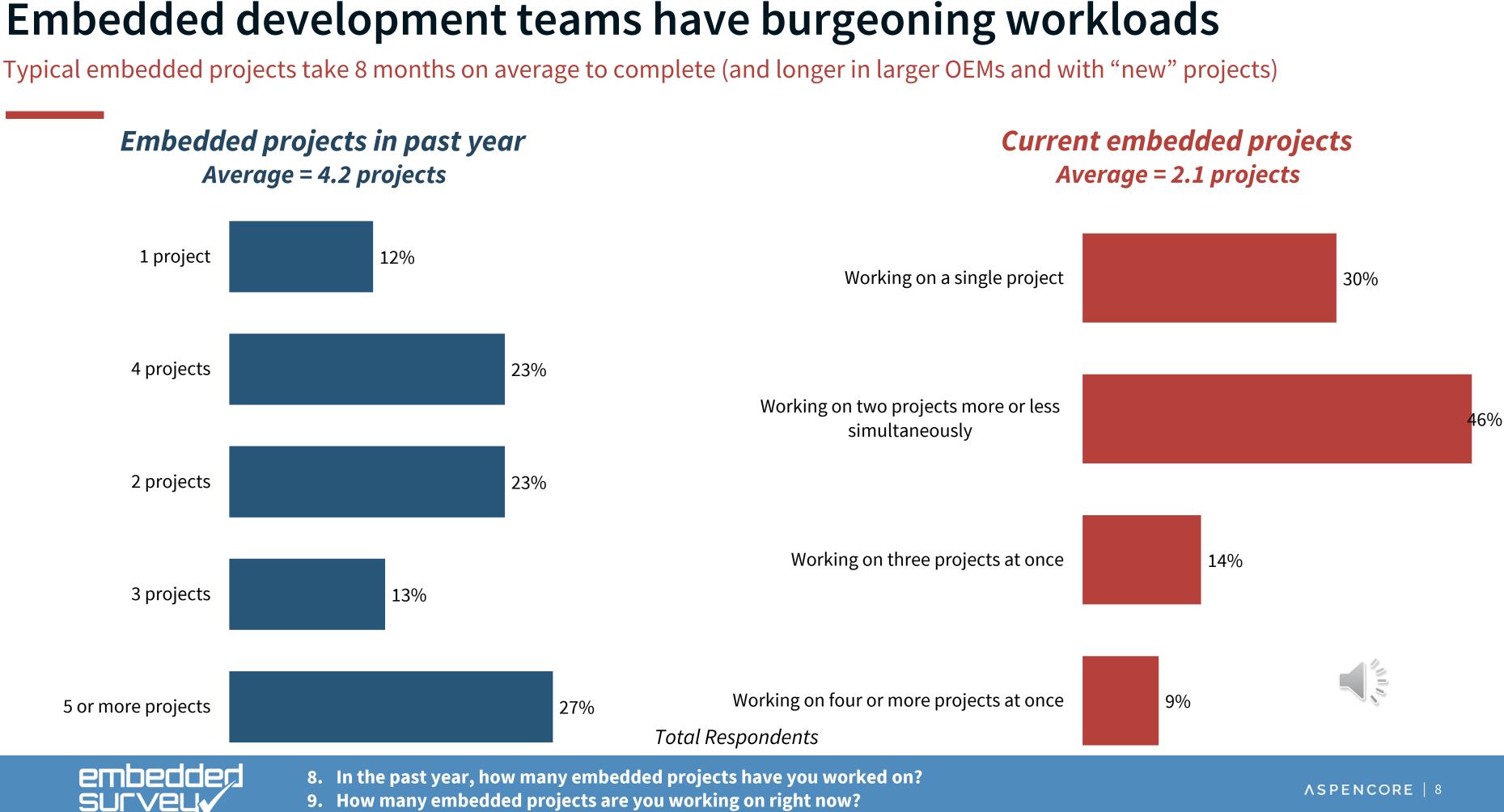


3. Which of the following capabilities does your current embedded project include?

Total Respondents

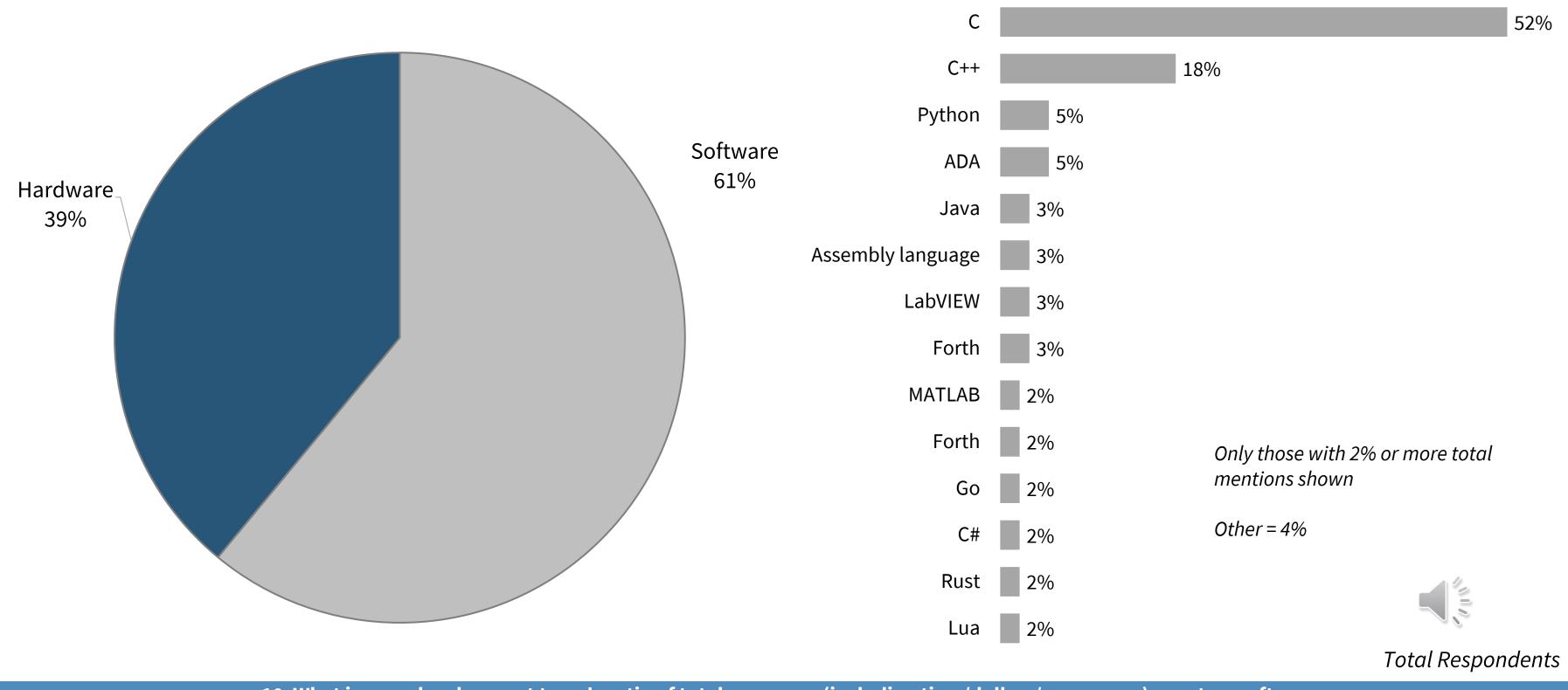
ASPENCORE 7

Average = 4.2 projects



Software development requires more cycle time

"C" dominates other languages for embedded software programming



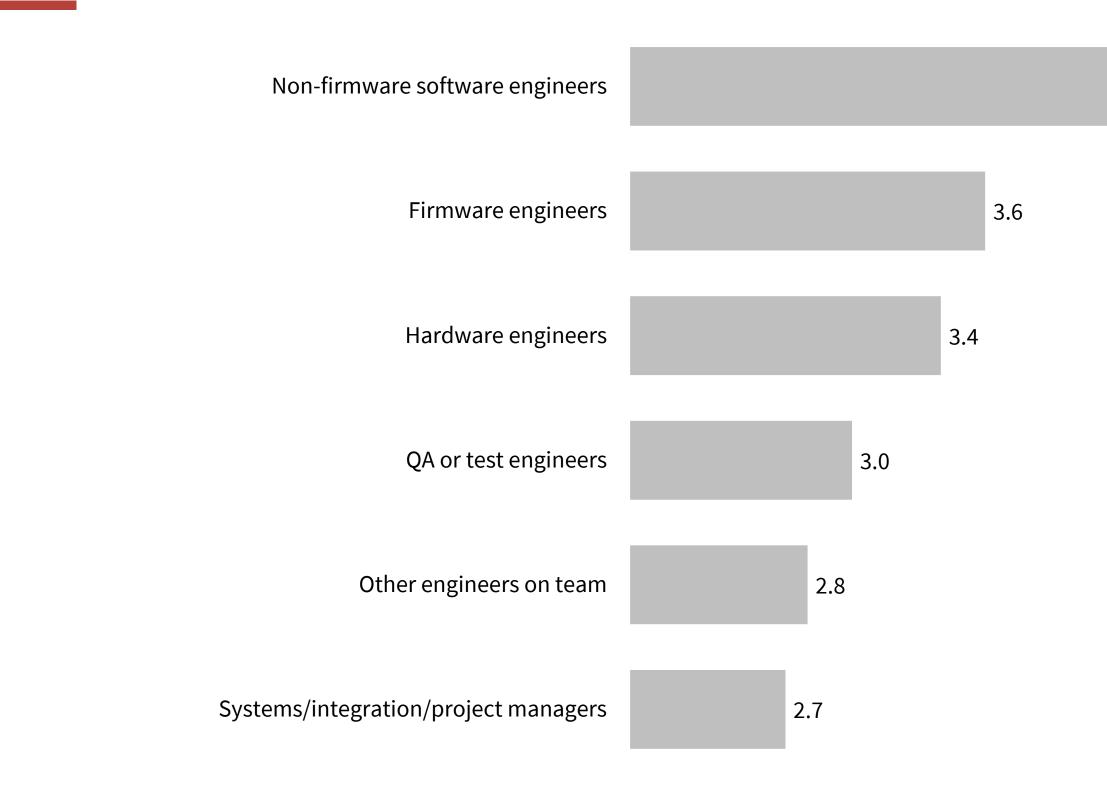


10. What is your development team's ratio of total resources (including time/dollars/manpower) spent on software vs. hardware for your embedded projects?

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





7. How many of the following types of engineers are on your current embedded project team?

4.3

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)

embedded

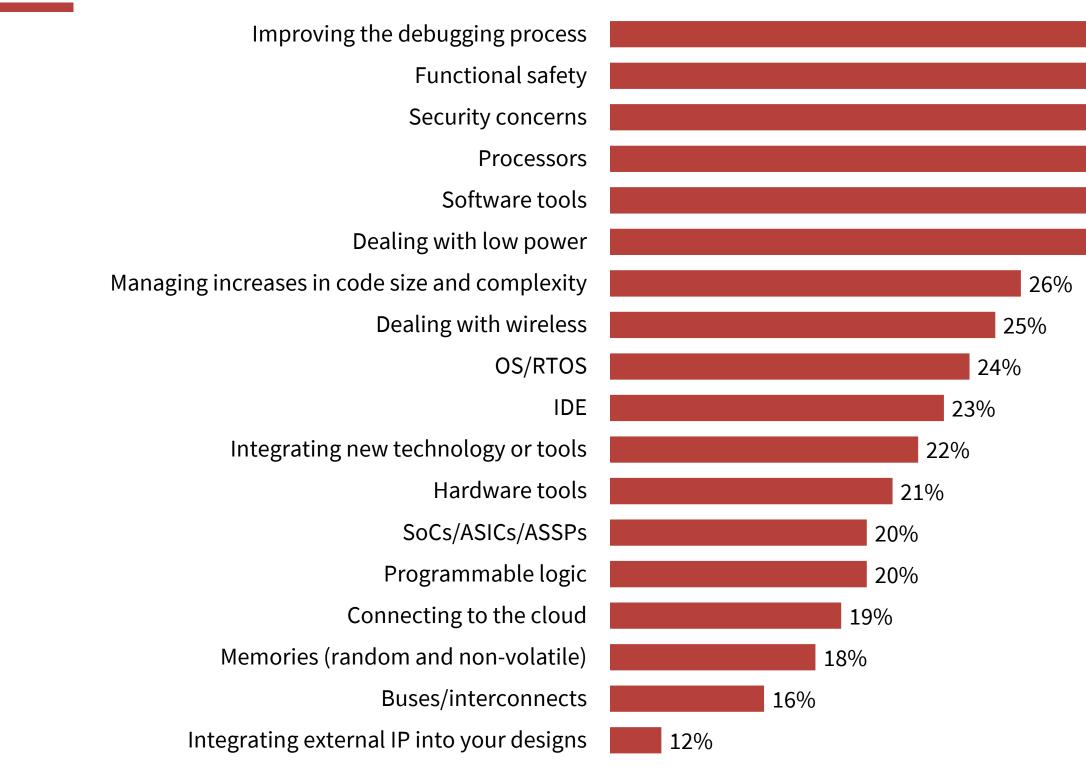
SUrvel

Meeting application performance requirements		52%
The debugging process	41%	
Testing/Systems Integration	40%	
Selecting the right processors for the job	39%	
Meeting functional safety or development process standards	32%	
Meeting schedules	32%	
Ensuring data security	32%	
Power management/Energy efficiency	31%	(Mary Line a subscript)
Providing network connectivity	31%	'Very Important'
Sticking to our cost budget	30%	Summary
Ensuring code/IP security	29%	
Software compatibility when porting to new devices	29%	
Keeping pace with the increased lines of code and complexity of embedded software	25%	
Connected device security from trust to provisioning, authentication and lifecycle	. 24%	
Keeping pace with new embedded systems technology	24%	
Ensuring security of third-party software resources (eg, libraries, APIs, etc)	24%	
Maintaining legacy code	22%	
Managing an increasingly remote design team and process at multiple locations	19%	
Managing multiple operating environments	13%	
Migrating to a multi-core processor	13%	12
Outsourcing and its influence on the embedded development process	13%	
Configuring or selecting scalable cloud or external data services	12%	Total Respondents

14. How important are the following challenges regarding your current embedded systems development process to you or your design team?

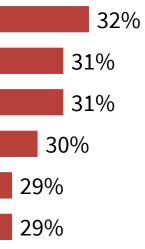
Total Respondents

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



embedded survey

20. Thinking about next year, how important will the following technology challenges be regarding future embedded designs?



APAC design teams are especially concerned about nearly all these issues

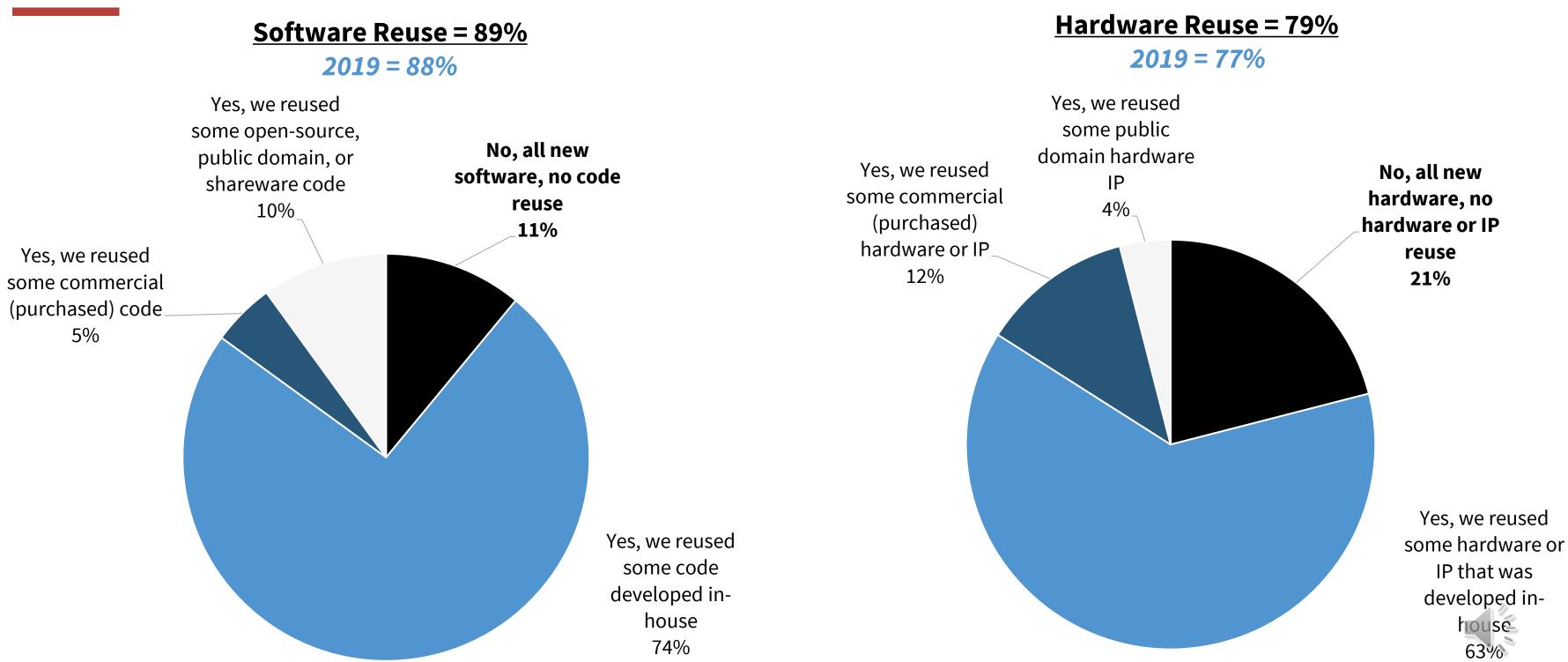
'Very Important' Summary



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



17. Does your current project reuse code from a previous embedded project? 18. Does your current embedded project reuse hardware or hardware IP from a previous project?

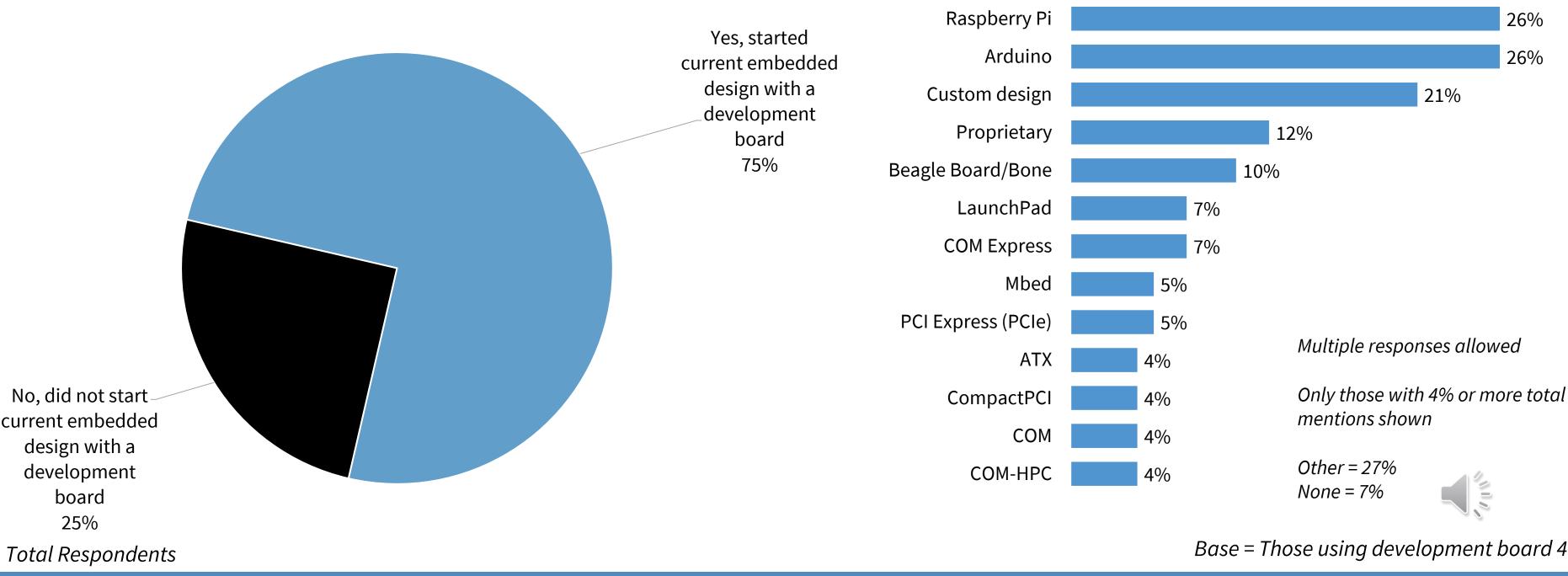
embedder

SULVER

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





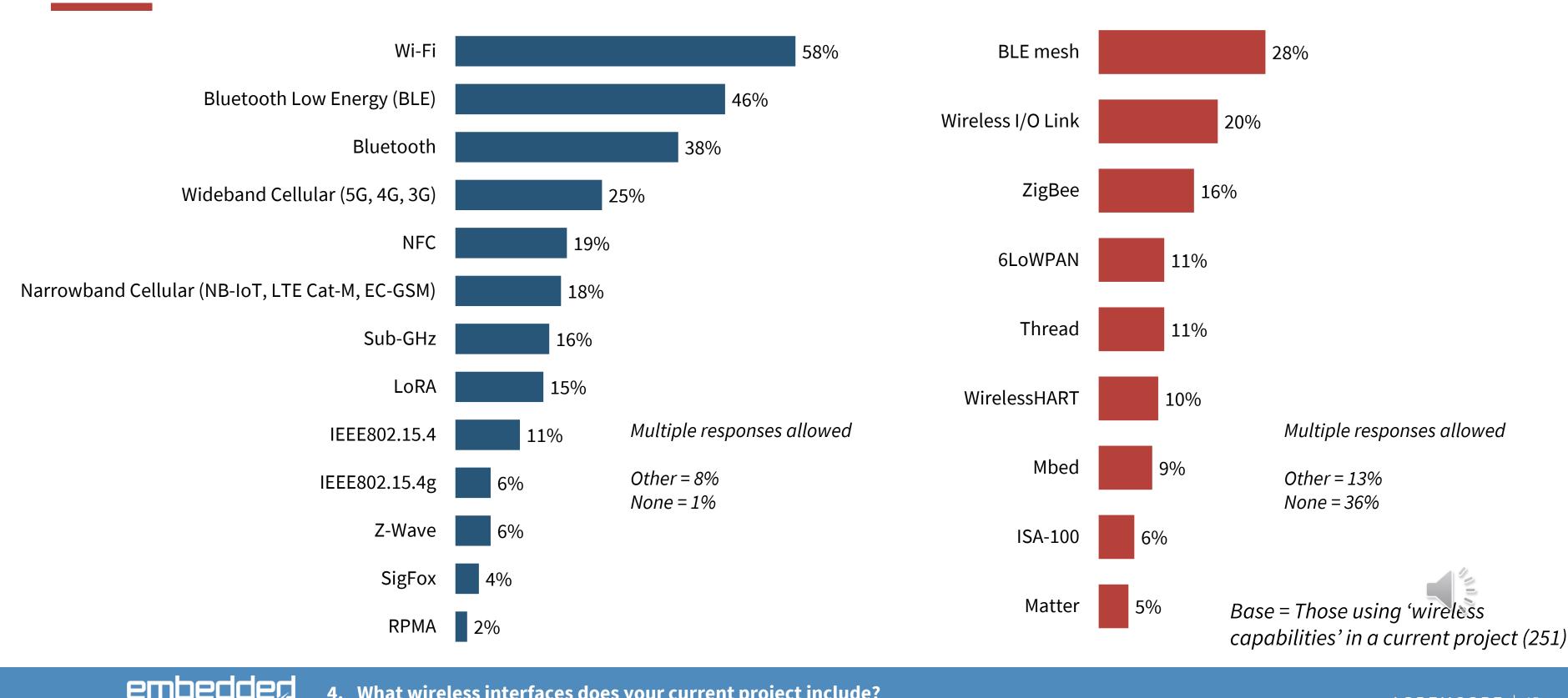
12. Did you start your current embedded design with a development board? 13. Which development boards are you currently using?

Board Used in Current Design(s)

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

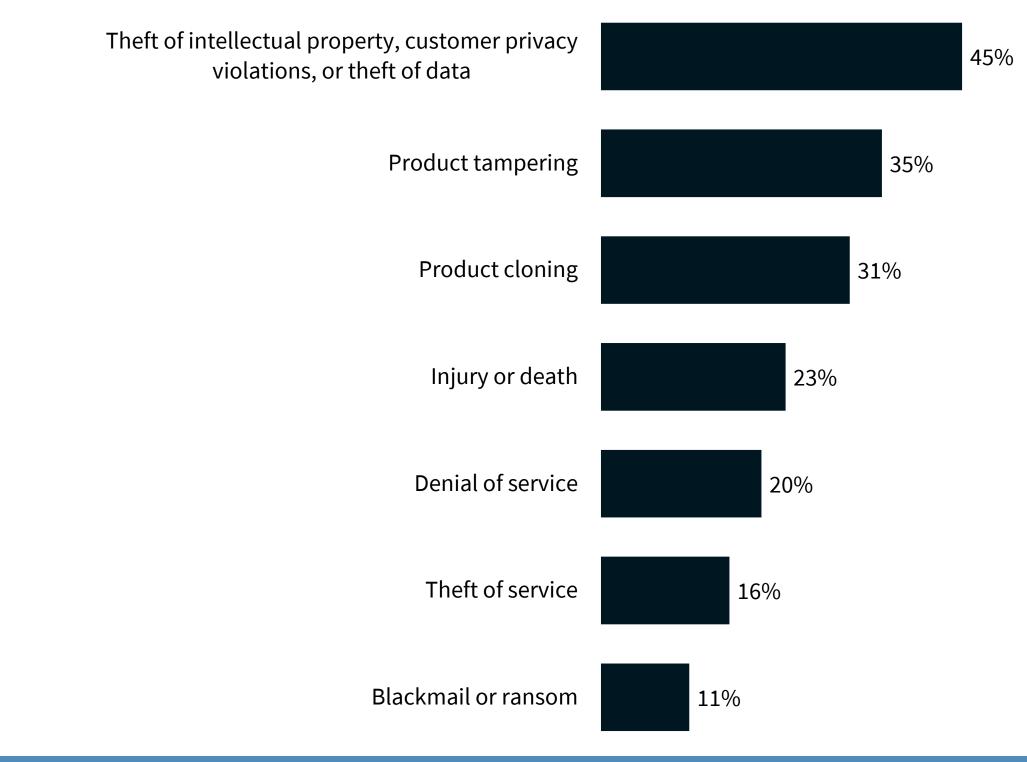


4. What wireless interfaces does your current project include?

SU

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





21. What are the primary security concerns with your current project?

Multiple responses allowed

Other = 2%*None* = 9%

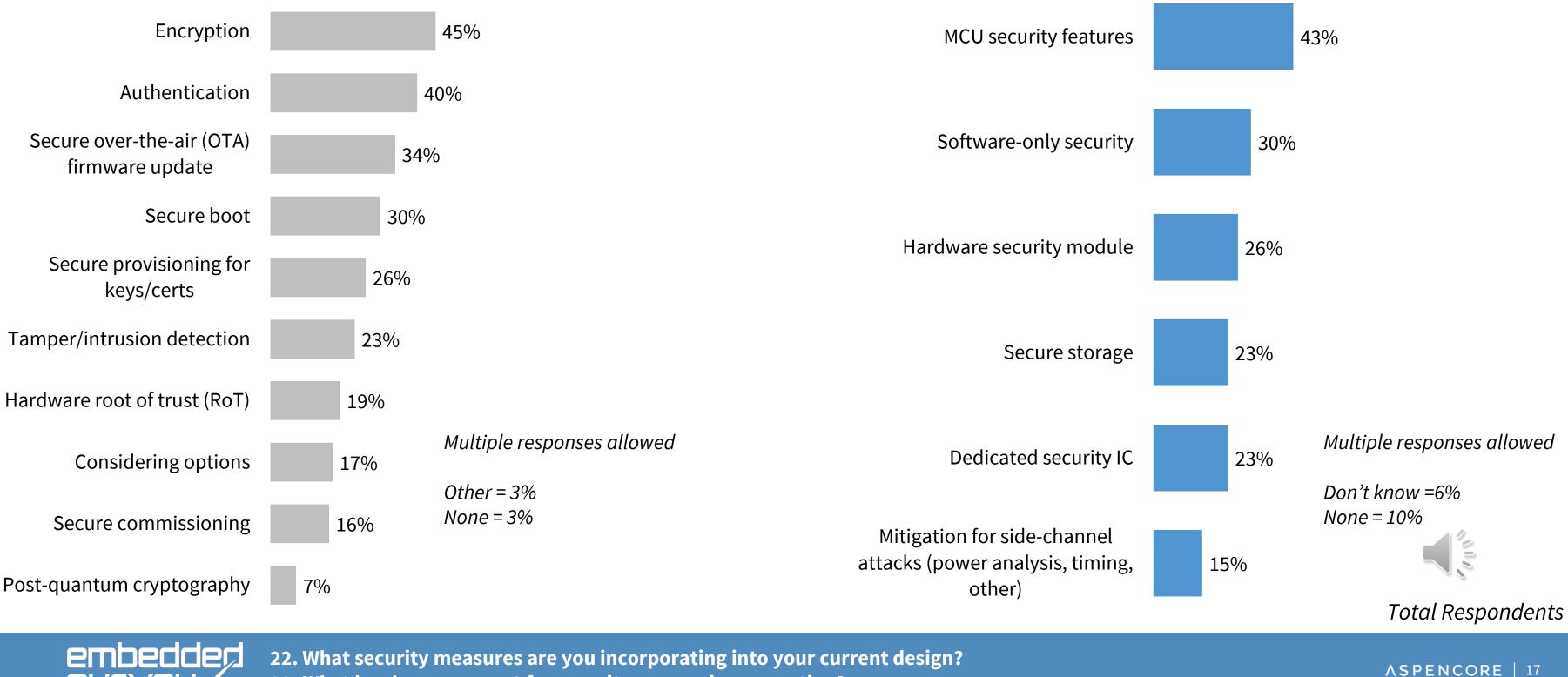


Total Respondents

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



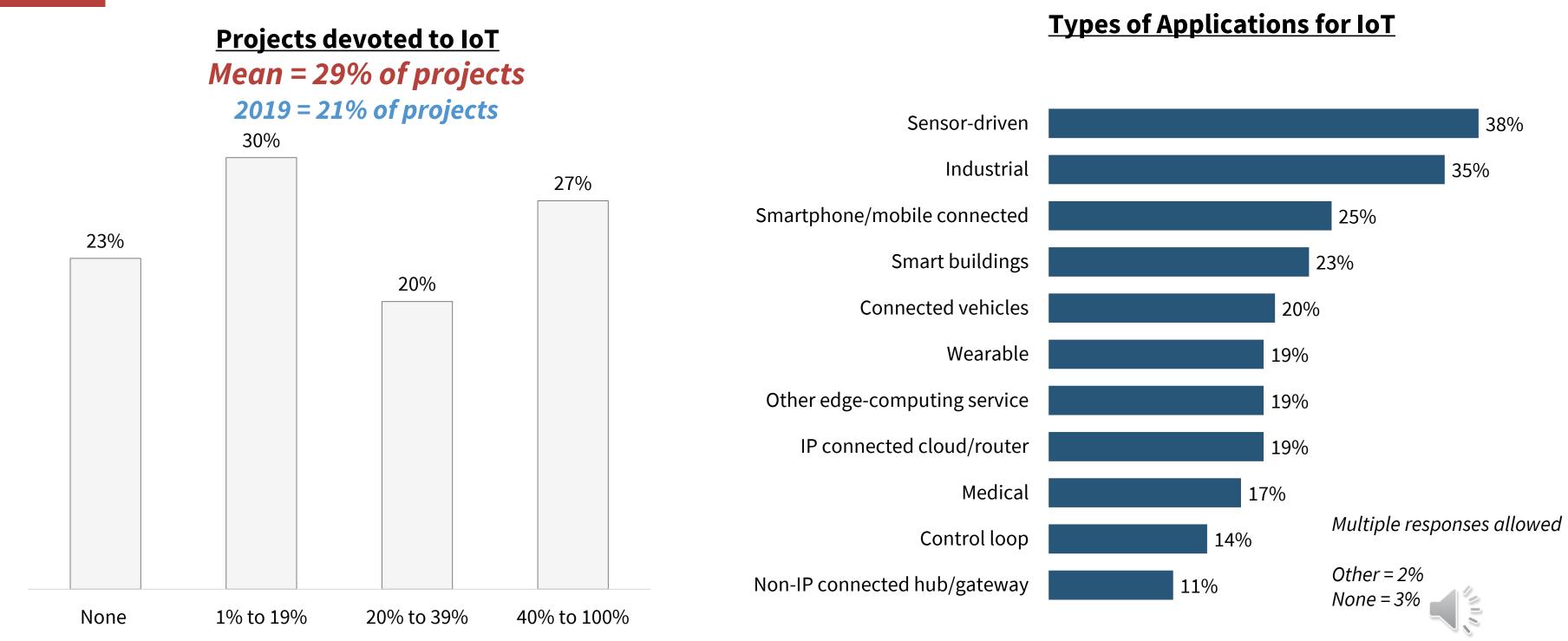
SULVER

23. What hardware support for security are you incorporating?

Hardware support for security

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



Total Respondents

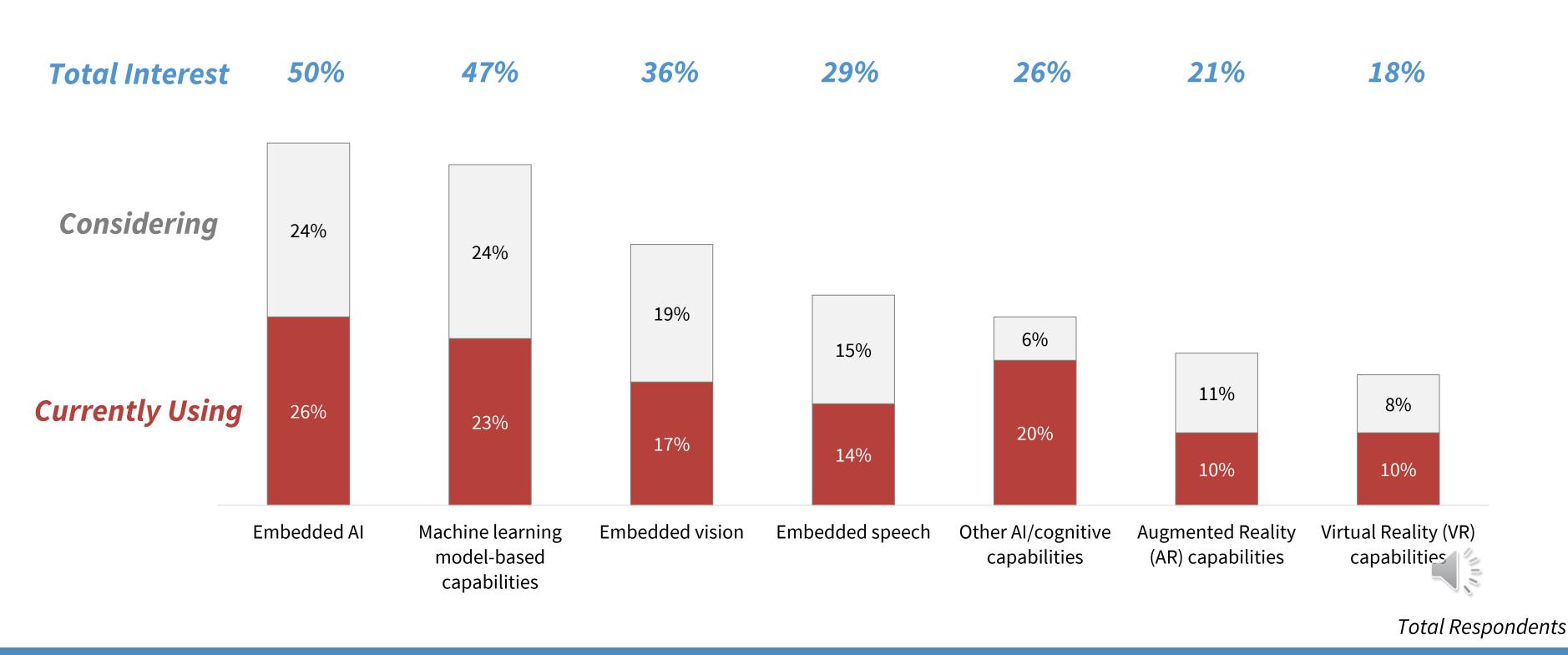
embedded

- 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.

Base = Those primary devoted to IoT applications (870)

Embedded development makes use of advanced technology capabilities

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



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

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Operating Systems



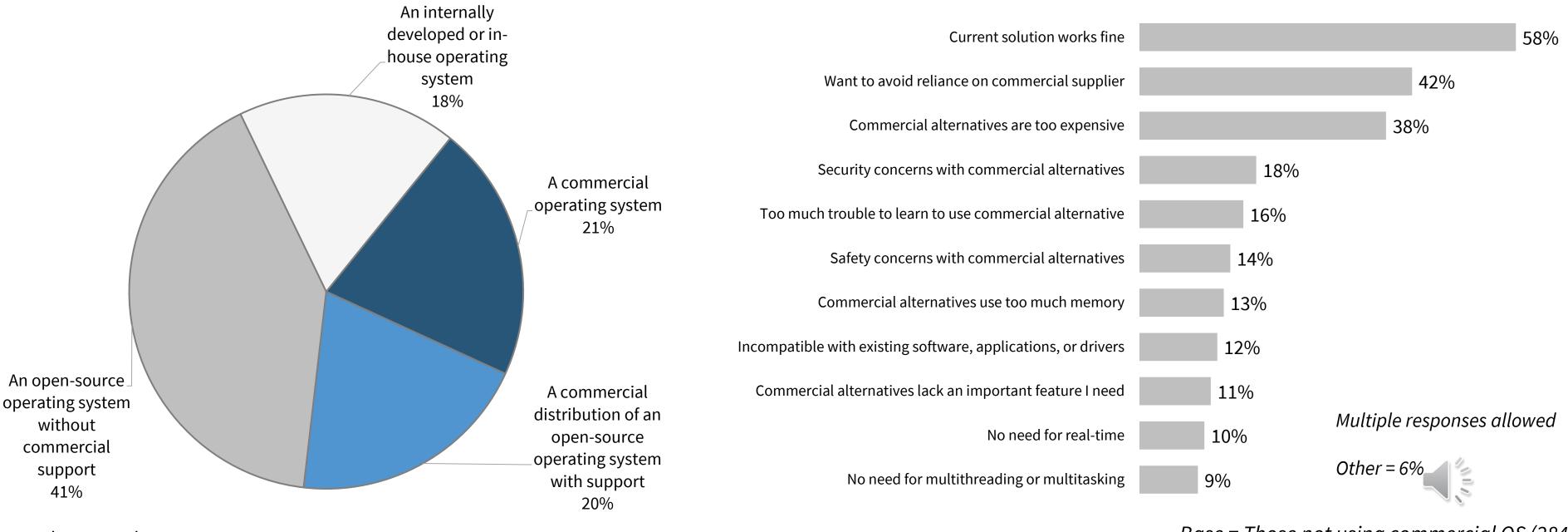


Most embedded projects utilize an operating system

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

embedder

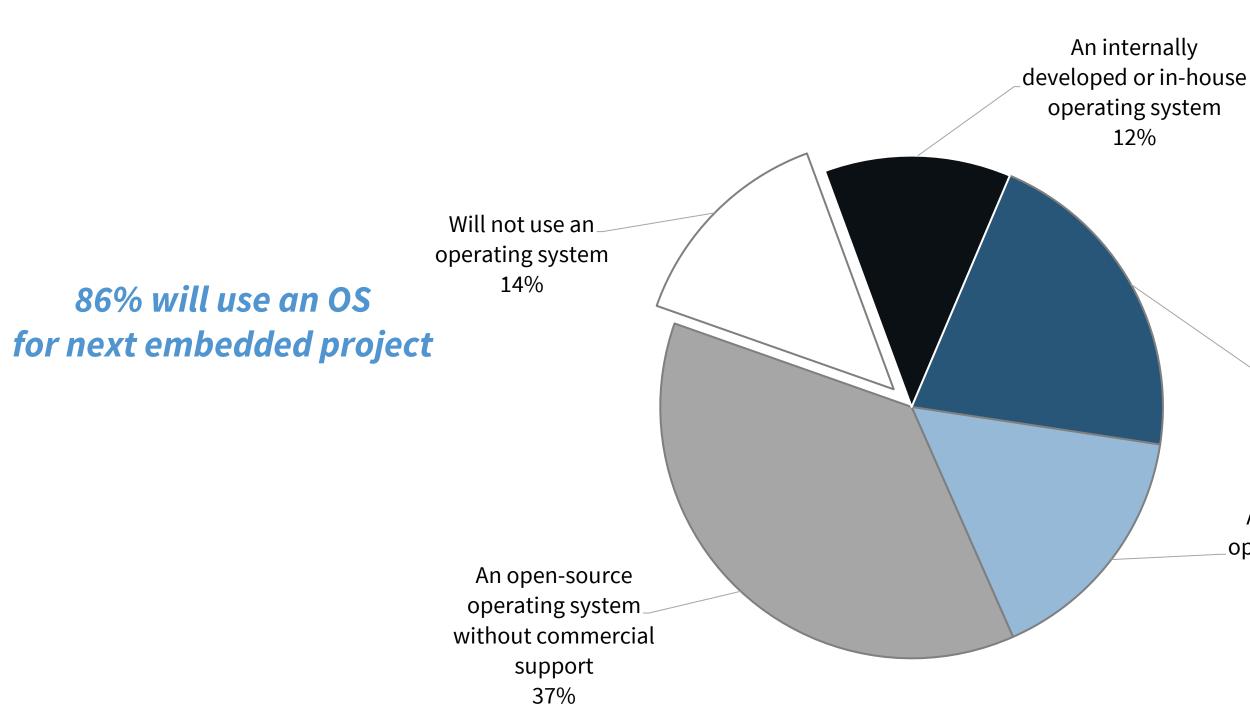
- 29. Does your <u>current</u> embedded project use an operating system, RTOS, kernel, software executive, or scheduler of any kind?
- **30. My current embedded project uses:**
- 31. 31. What are your reasons for <u>NOT currently</u> using a commercial operating system?

<u>Reasons for not using commercial OS</u>

Base = Those <u>not using</u> commercial OS (284)

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

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





SULVER

A commercial distribution of an open-source operating system with support 21%

A commercial operating system 16%

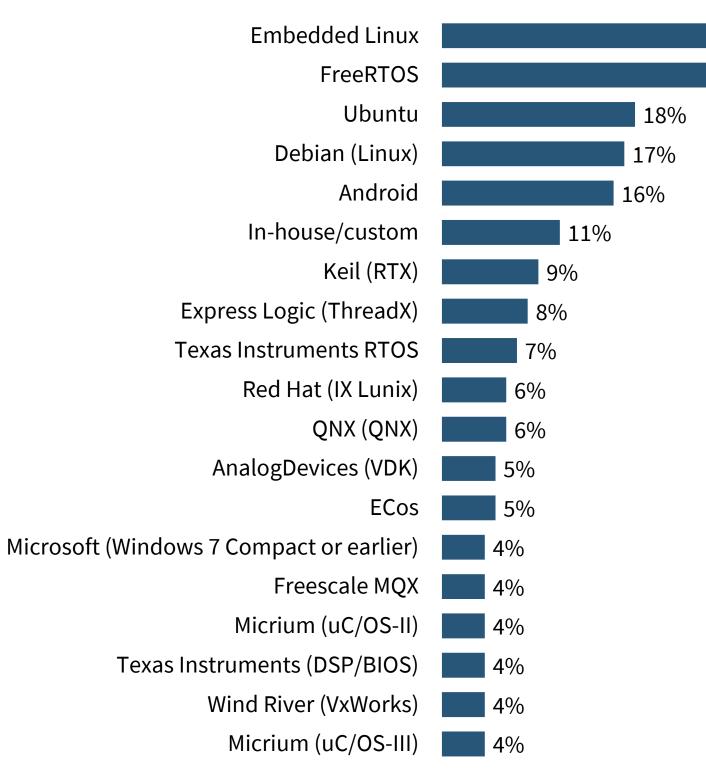


Total Respondents

ASPENCORE 22

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





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SUrvel

44% 44%

Multiple responses allowed

Only those with 4% or more total mentions shown

Other = 7%

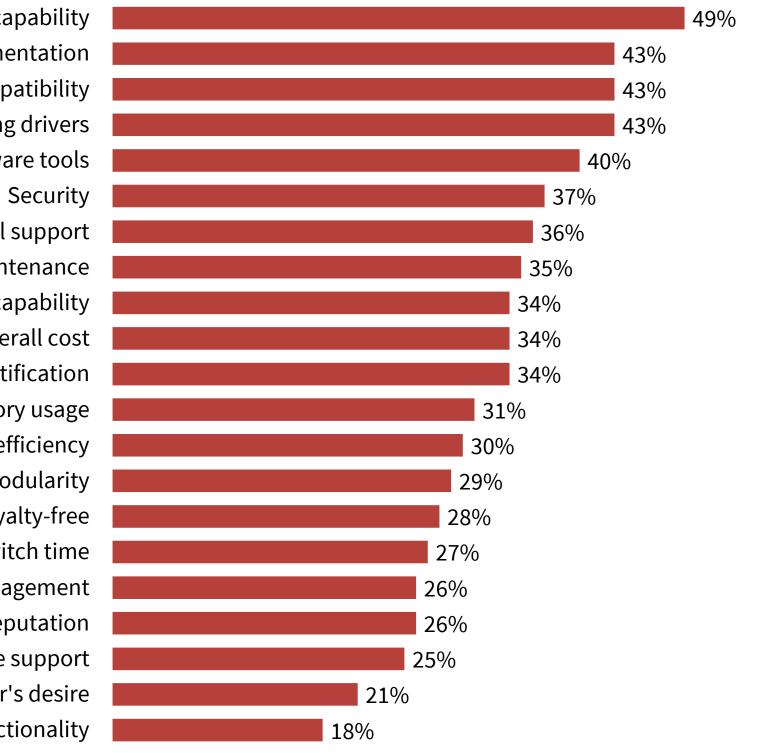


Base = Those who will use an OS (566)

ASPENCORE 23

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



Real-time capability Documentation Processor or hardware compatibility Support for my processor including drivers Good software tools Technical support Ease of future maintenance Networking capability Overall cost Safety Certification Code size / memory usage Scheduling efficiency Modularity Royalty-free Context switch time Power management Supplier's reputation Multicore support Customer's desire Hypervisor functionality



32. How important are the following factors regarding your decision to use a commercial operating system, RTOS, kernel, etc.?



Multiple responses allowed



Base = Those <u>using</u> commercial OS (200)

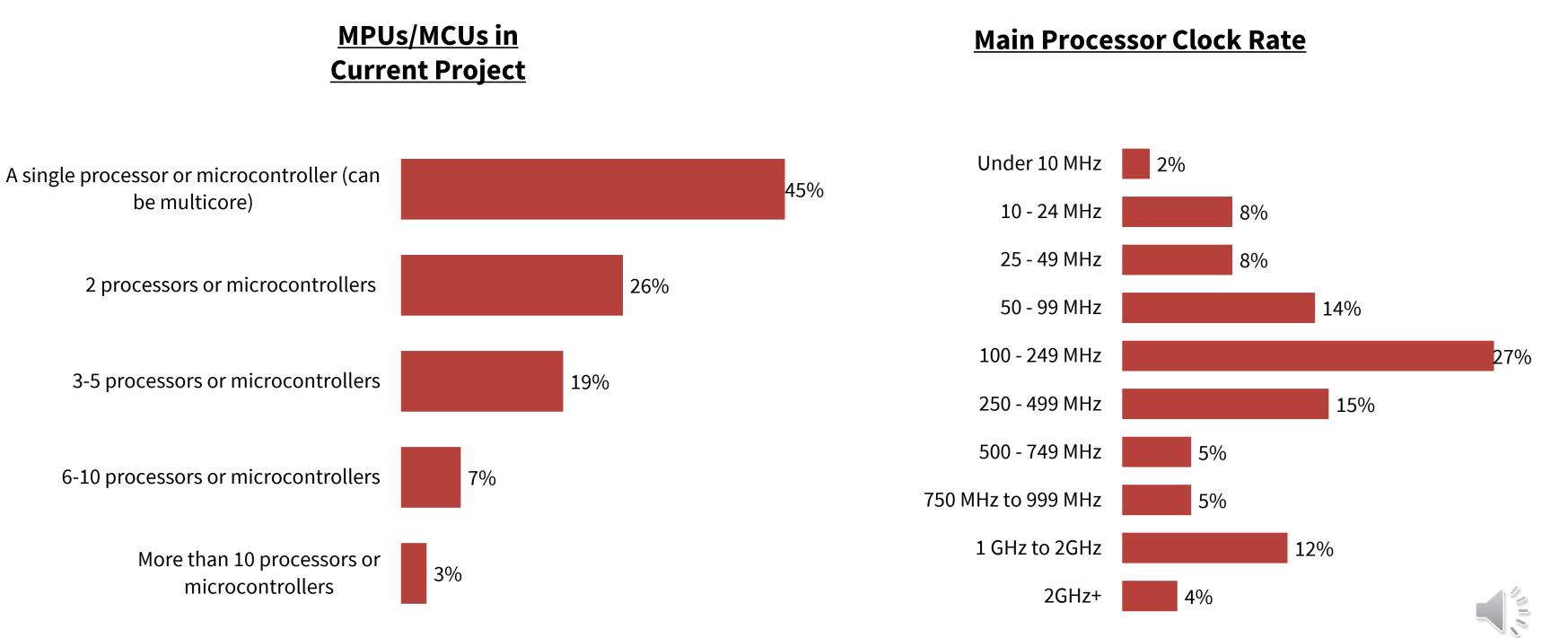
Microprocessors / Microcontrollers / FPGAs





Most embedded projects use multiple processors

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



38. My current embedded project contains: 42. My current embedded project's main processor clock rate is:

embedded

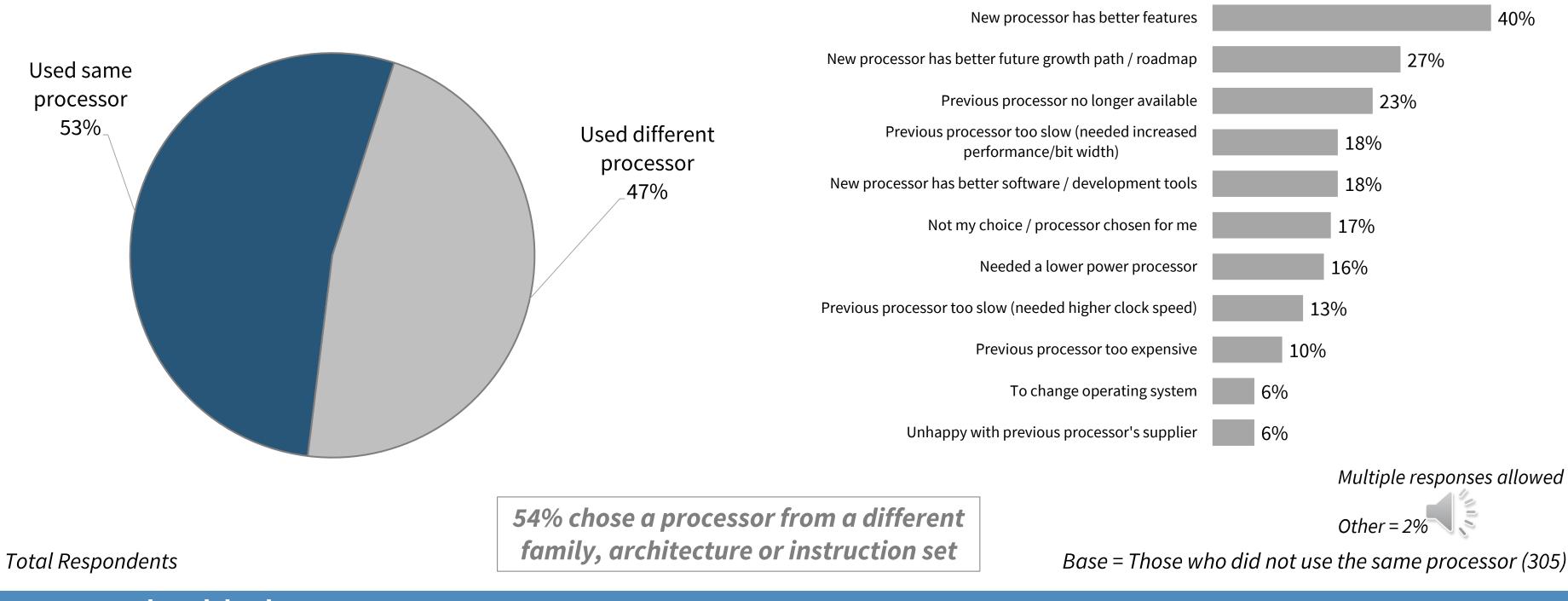
SUrvel

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





embedder

43. Did you use the same processor in your previous embedded project? 44. Why did you use the same processor?

Reason for Switching Processors

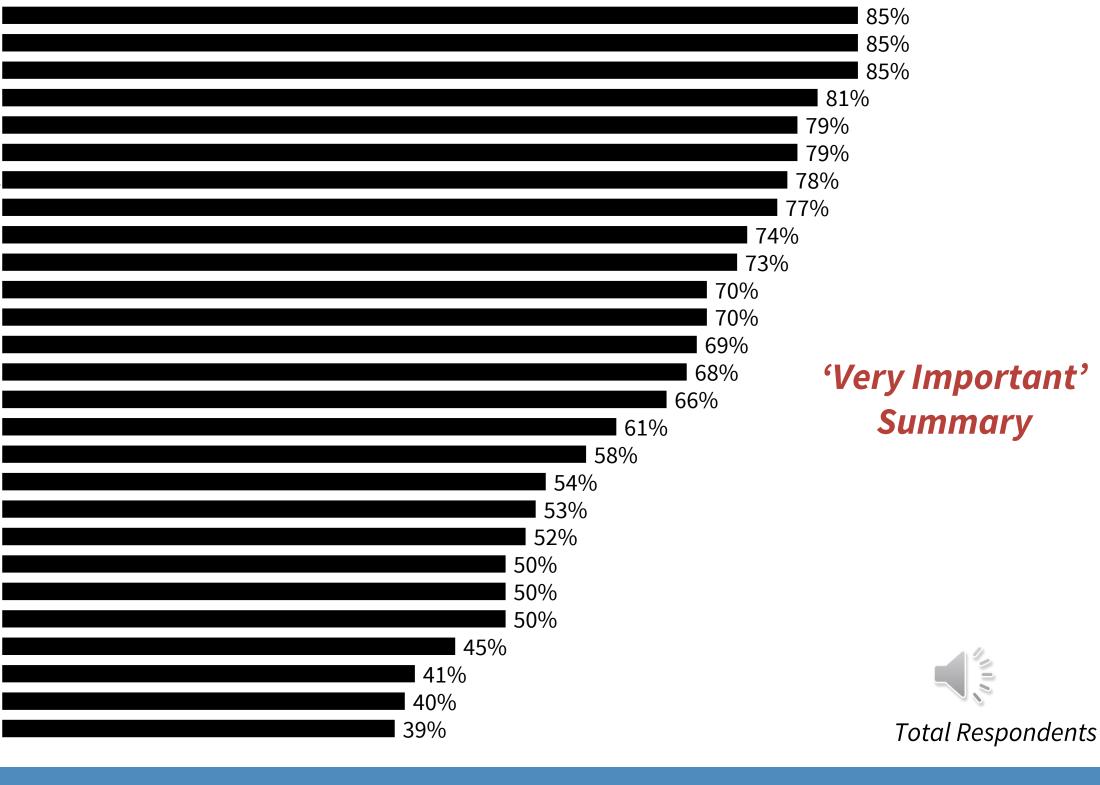
ASPENCORE 27

Processor selection involves weighing many interrelated factors

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

The chip's performance The on-chip I/O or peripherals The software-development tools available for it (compilers, debuggers, etc.) The processor's debug support The "ecosystem" surrounding the chip (software, tools, RTOS, support, etc.) The software already available for it (middleware, drivers, existing code, etc) The hardware-development tools available for it (emulators, scopes, dev kits,... The chip's cost My familiarity with the architecture / chip family The supplier's reputation The chip family's future roadmap or growth path The chip's power consumption The operating systems it supports The chip's supplier/vendor The chip's security features The chip's functional safety features The chip's floating-point performance The chip's popularity Availability of on-chip programmable logic The chip's MAC/DSP features Open instruction set architecture The chip has an integrated RF or radio capability, (e.g., a "wireless MCU") The supplier's other product line(s) The processor's availability as IP (for ASIC/SoC development) The chip has vector (SIMD) arithmetic Virtual prototype/transaction-level model available for it (e.g., SystemC-based... The ability to customize or add instructions to the processor

embedder





ASPENCORE 28

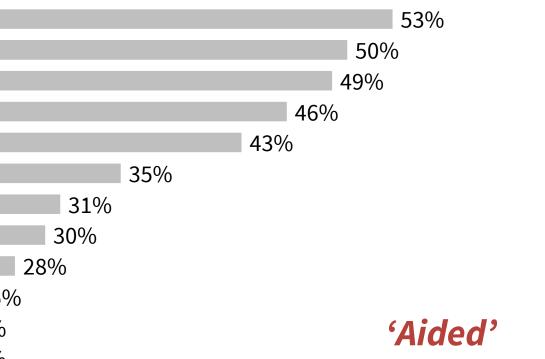
Familiarity with MPU/MCU vendors

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

STMicroelectronics		
Microchip Technology		
Texas Instruments		
Intel		
NXP		
AMD		
Analog Devices		
Infineon		
Renesas		
Broadcom		25%
Qualcomm		24%
Silicon Labs		24%
NVIDIA		21%
Samsung	16%	
Cirrus Logic	15%	
Zilog	14%	
Lattice Semiconductor	13%	
Marvell	13%	
IBM	12%	
Digi/Rabbit Semiconductor	9%	
Toshiba	8%	
Spansion	6%	
VIA	2%	
Stretch	1%	



48. Select the processor vendors you are familiar with:



Familiarity

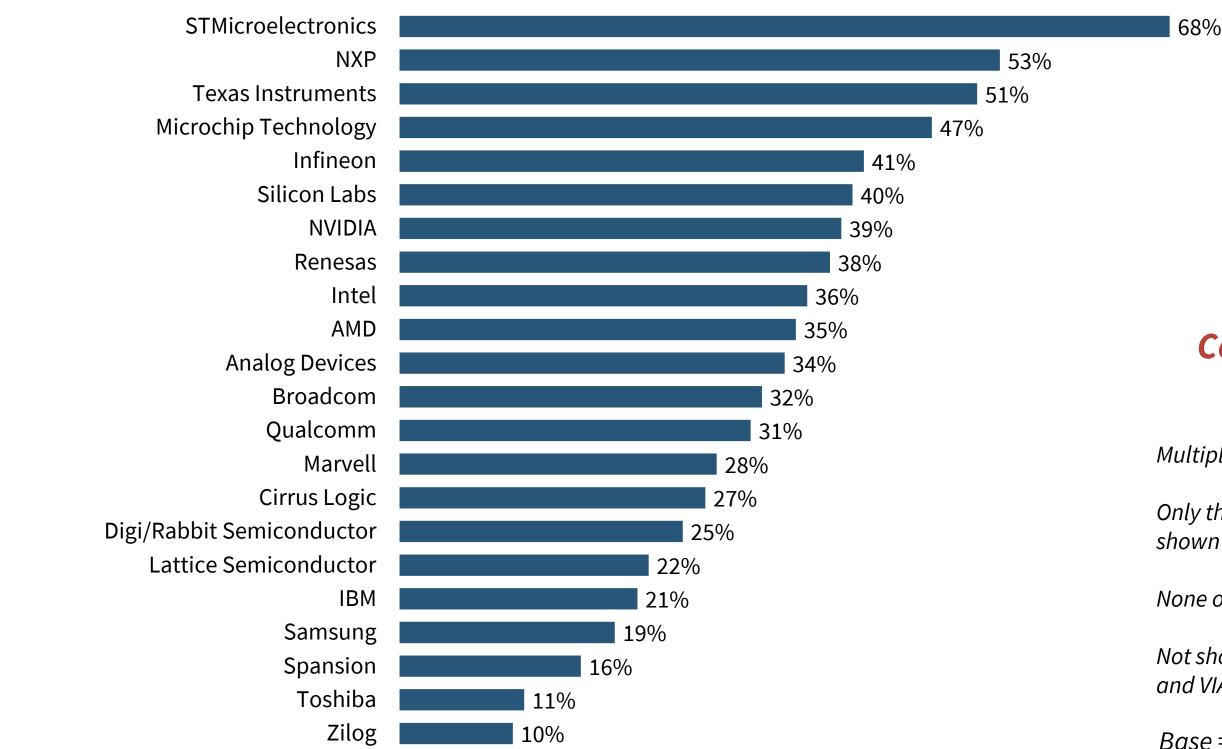
Multiple responses allowed



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





50. Select the processor vendors you will consider using in your next embedded project:

'Aided' **Consideration**

Multiple responses allowed

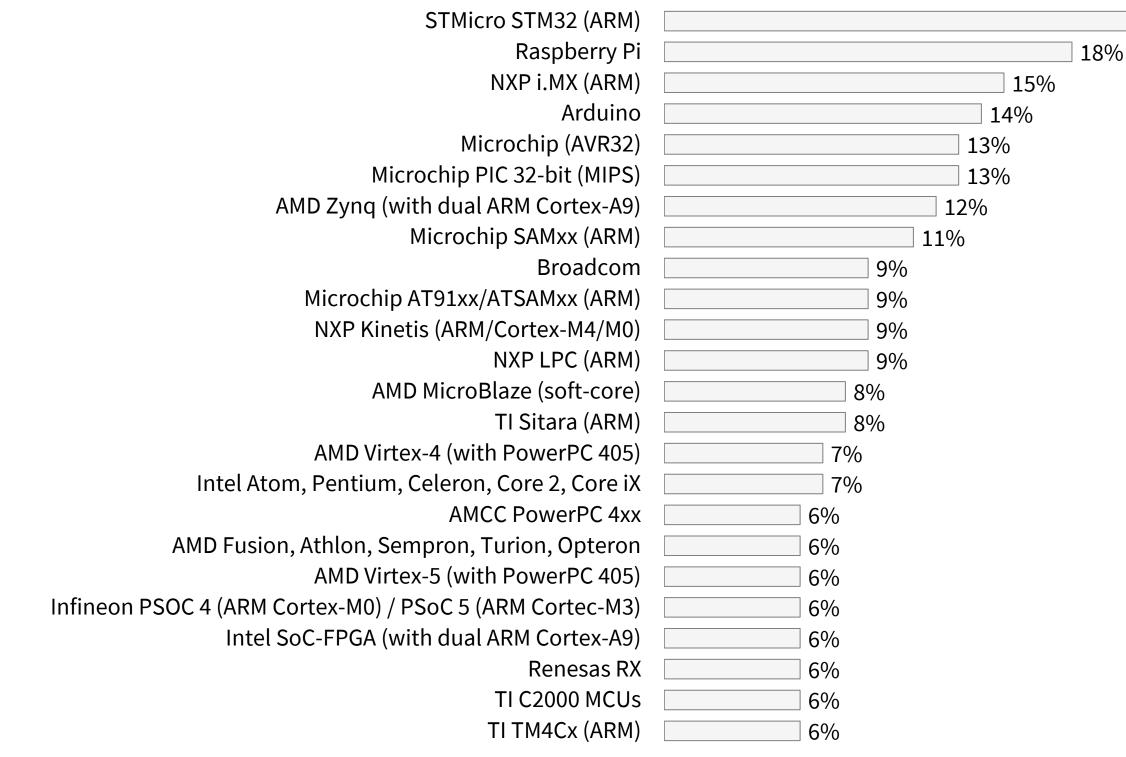
Only those with 4% or more total mentions shown

None of the above = 5%

Not shown due to small sample size: Stretch and VIA

Base = Those familiar with each vendor

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



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34%

Multiple responses allowed

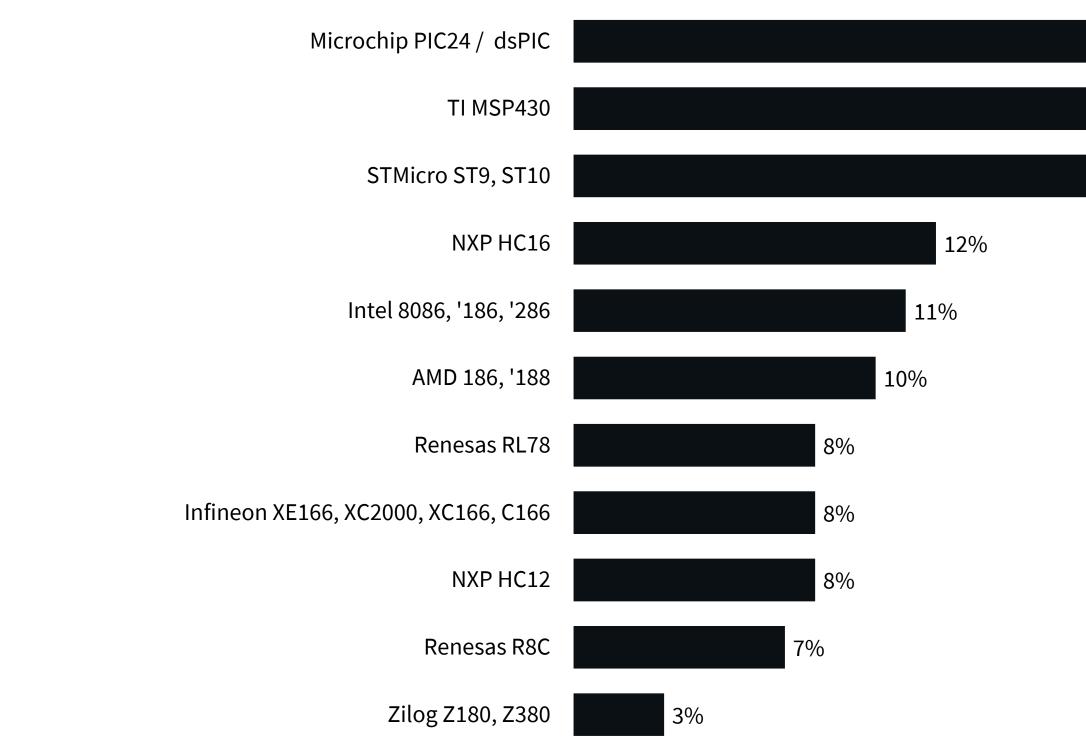
Only those with 6% or more total mentions shown

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





52. Which of the following 16-bit processor families would you consider for your next embedded project?

			24%
	18%		
17	′%		

Multiple responses allowed

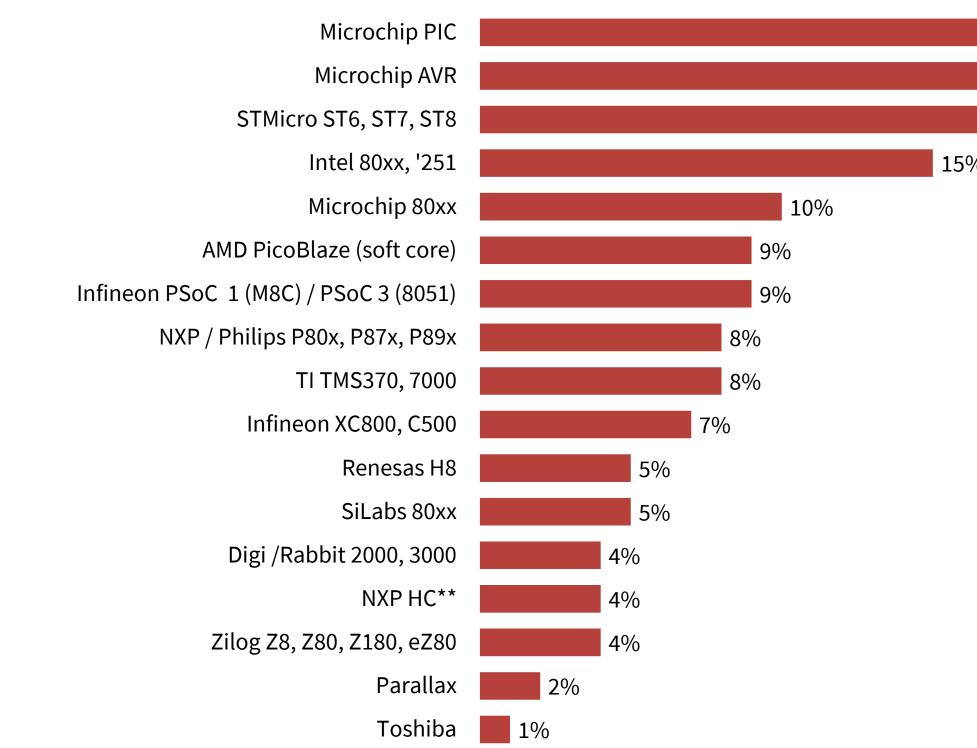
Other = 2% None of the above = 36%



Total Respondents

ASPENCORE 32

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





51. Which of the following 8-bit processor families would you consider for your next embedded project?

			23%
		20%	
	18%		
6			

Multiple responses allowed

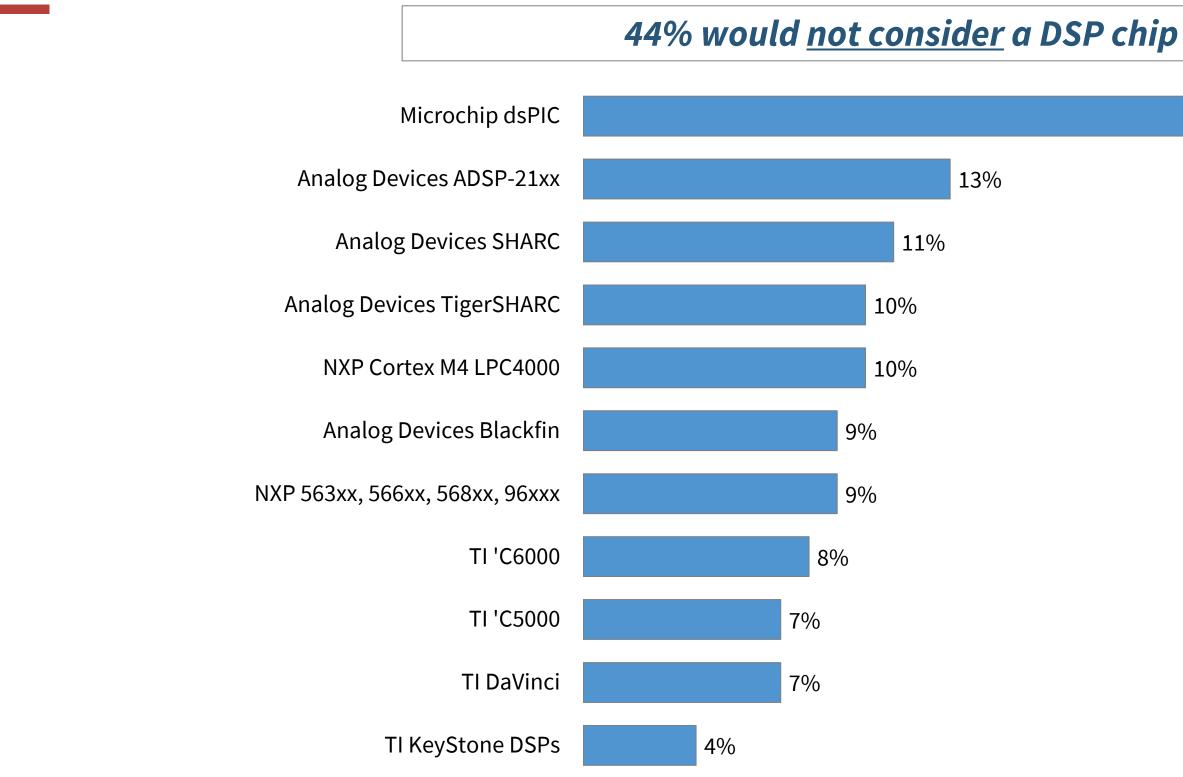
Other = 5% None of the above = 31%



Total Respondents

Future consideration of DSP families

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





55. Which of the following DSP chip families would you consider for your next embedded project?

22%

Multiple responses allowed

Other = 2% None of the above = 44%



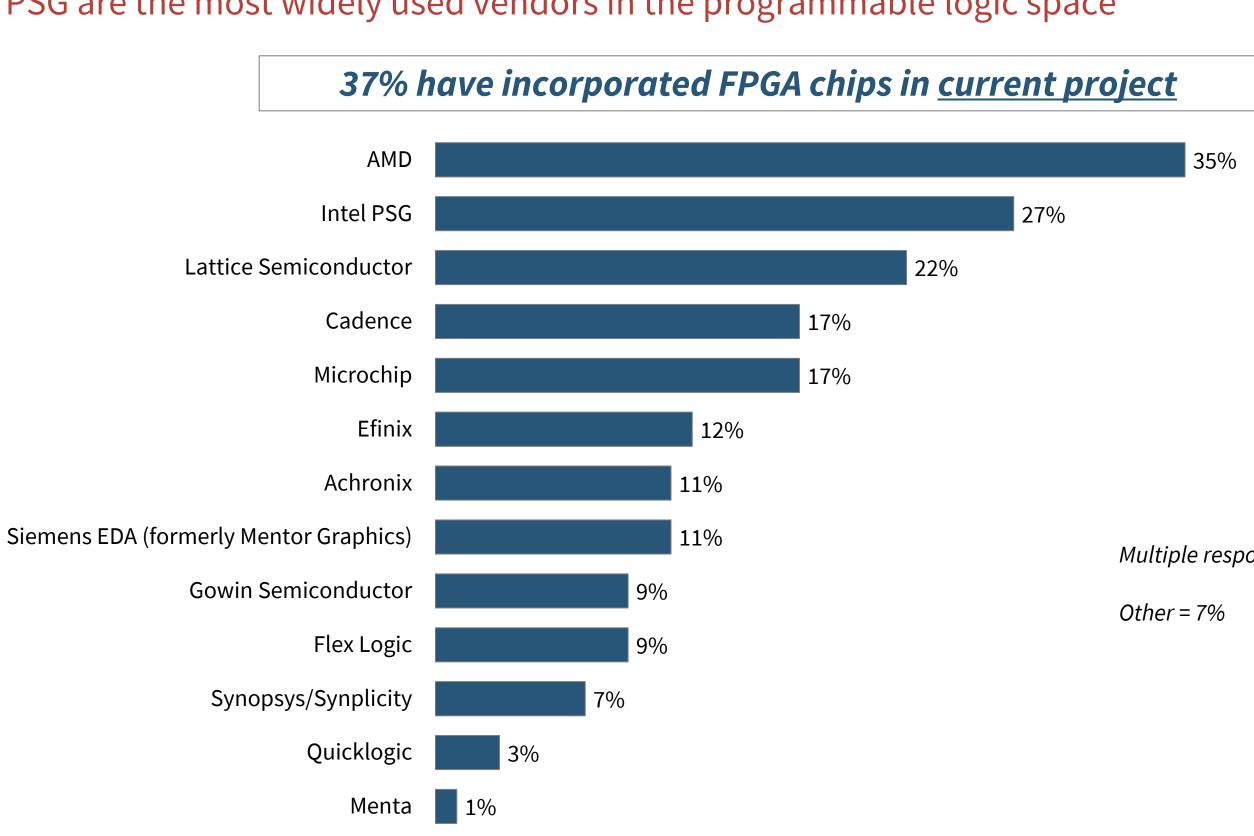
Total Respondents

Future consideration of FPGAs

embedded

SU

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



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?

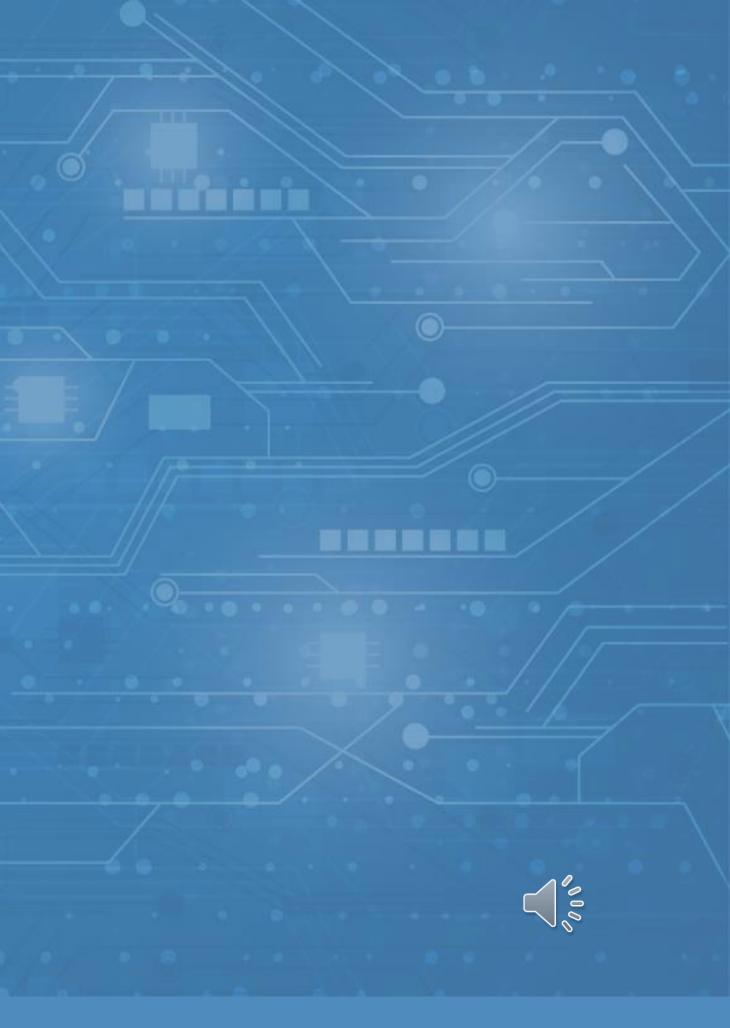
Multiple responses allowed



Total Respondents

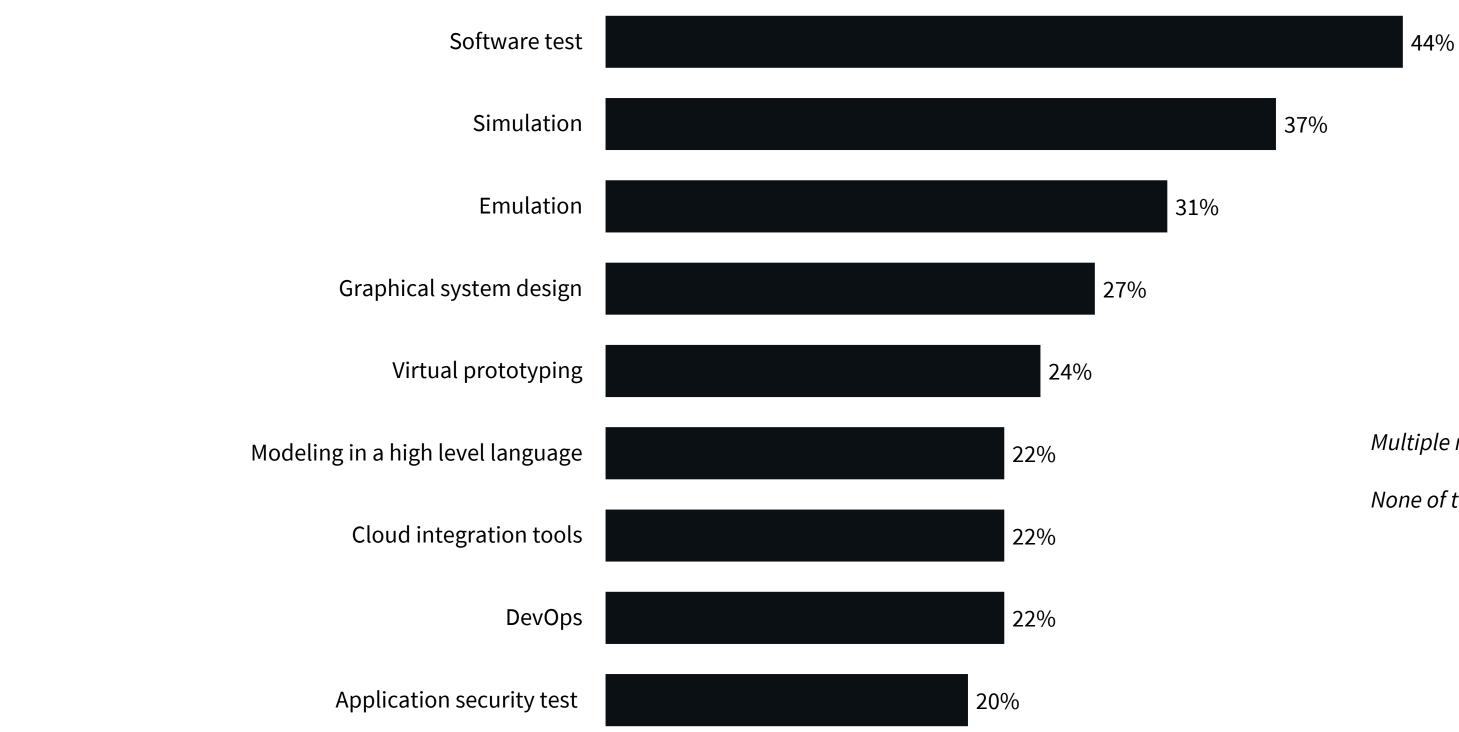
Design Tools





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





60. Which of the following design techniques will become more important to you in the future?

Multiple responses allowed

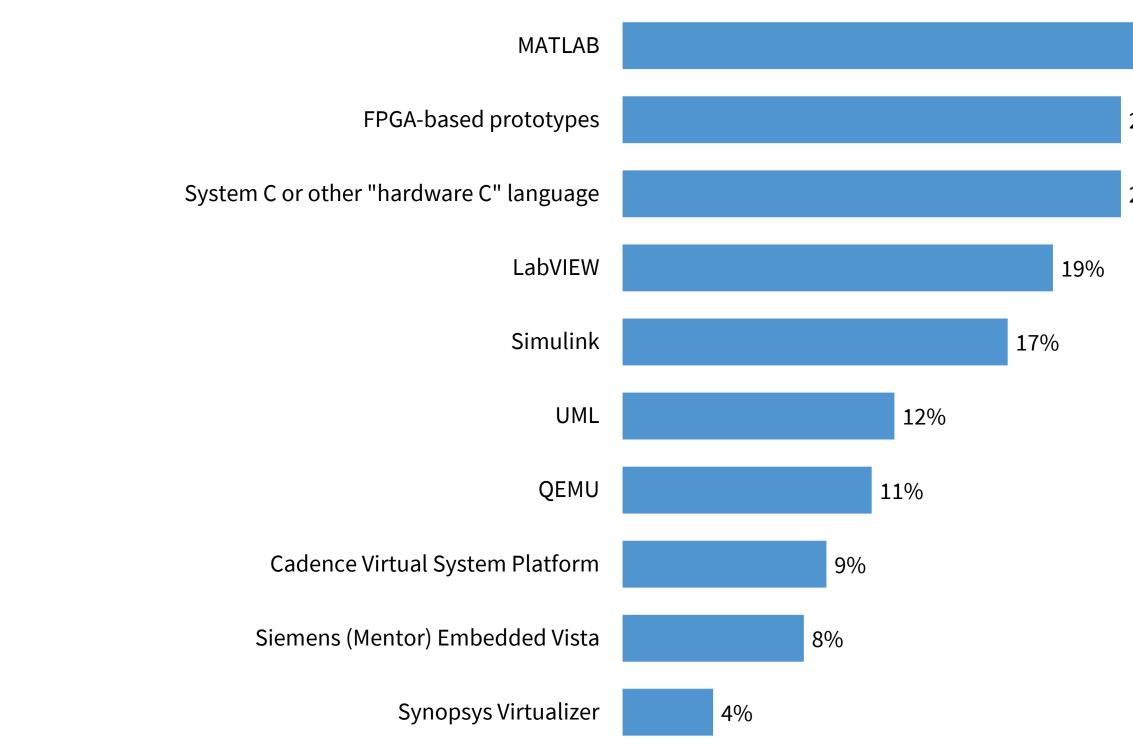
None of the above = 7%



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)





62. What system-level design tools do you or your organization <u>currently use</u>?

32%

22%

22%

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

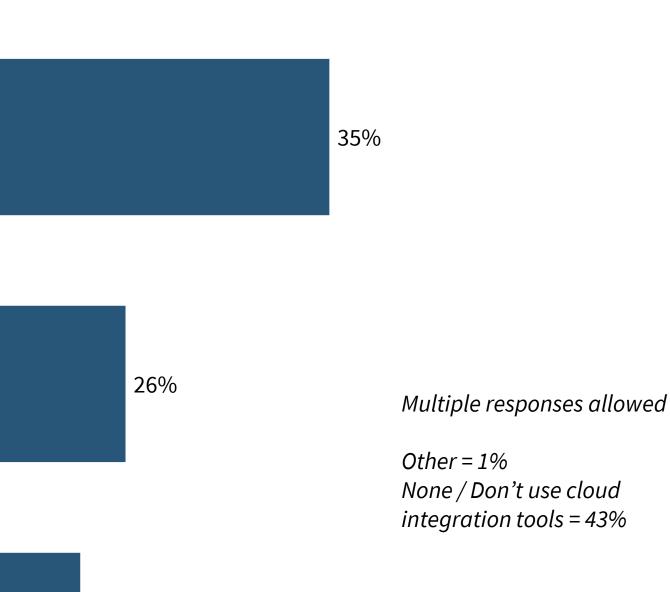
Firmware update

Security management (including auth and commissioning)

Device management (including device shadows)



63. Which cloud integration tools do you or your organization <u>currently use</u>?



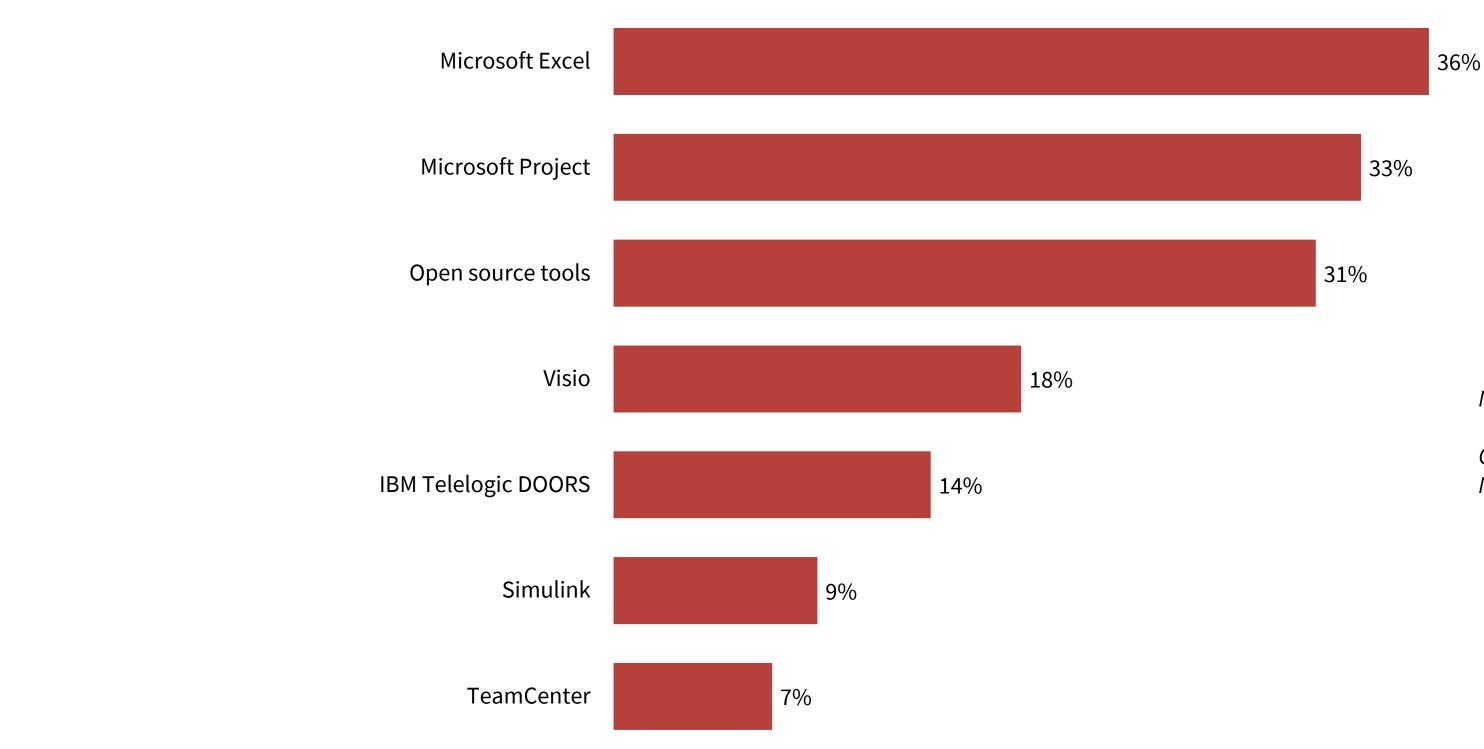
24%



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





64. Which of the following Project Management software packages do you currently use?

Multiple responses allowed

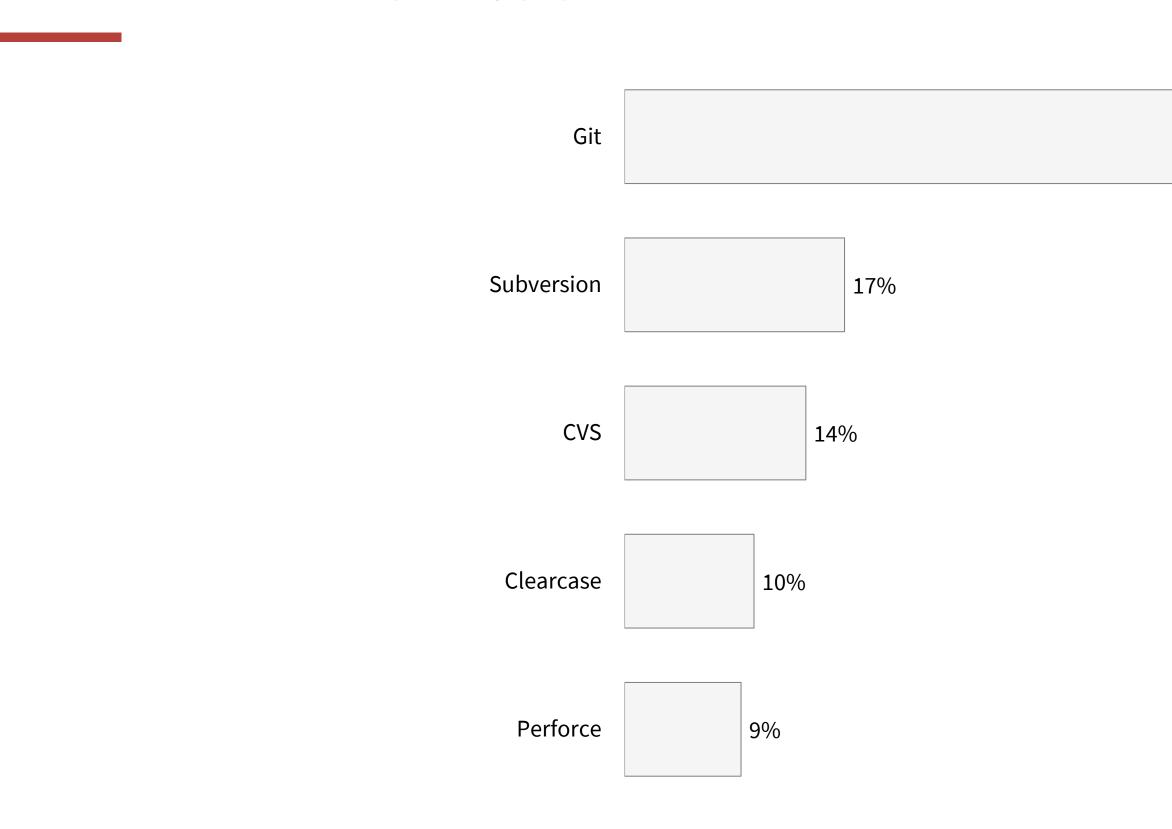
Other = 6%*None of the above = 19%*



Total Respondents

Git is the most widely used version control software

Git and Subversion are especially popular in EMEA





65. Which of the following Version Control software systems do you <u>currently use</u>?

63%

Multiple responses allowed

Other = 3%*None of the above = 14%*



Total Respondents



Information, Training & Continuing Education

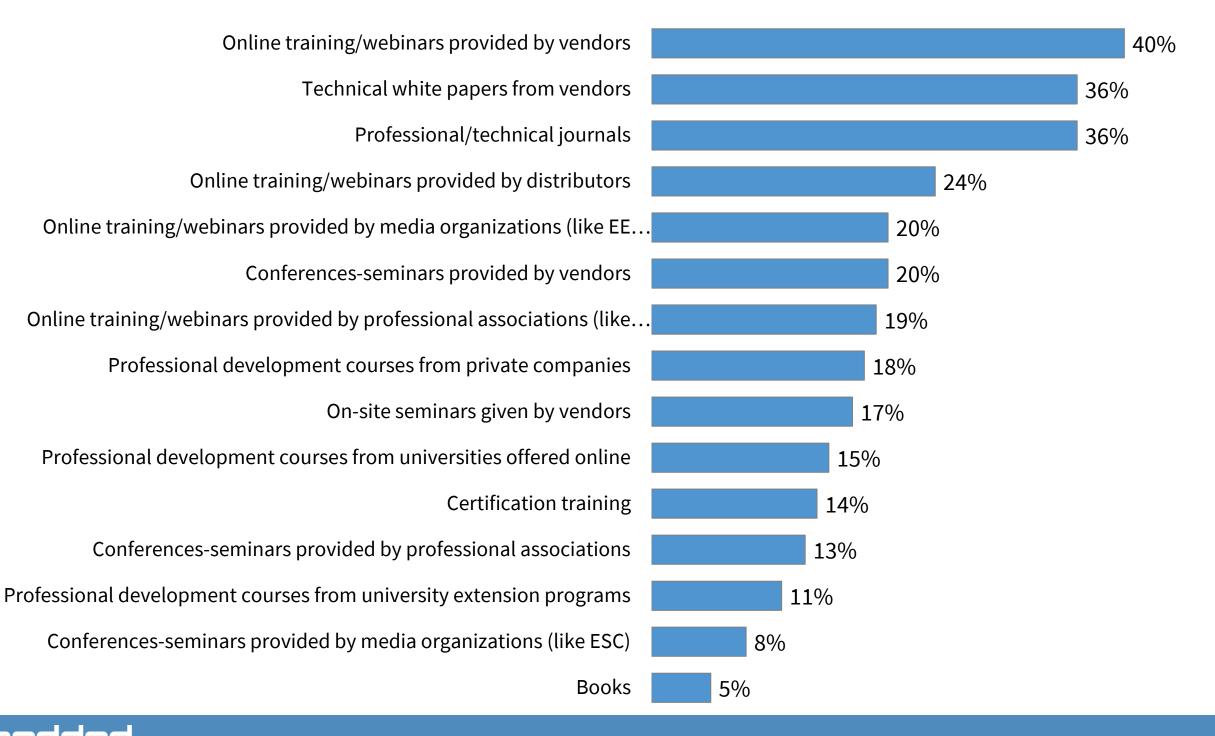




Most utilized methods for self-education on embedded development trends – online training, plus vendor white papers and professional/technical journals

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



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

embedder

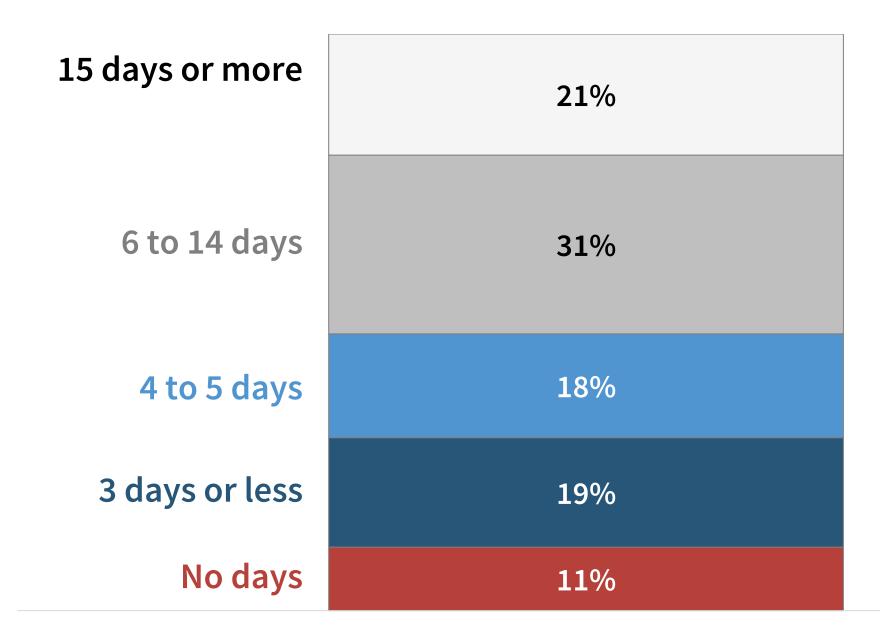


Total Respondents

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



embedded

SULVER

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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