2018

Embedded Systems Safety & Security Survey

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Executive Summary

In 2018, Barr Group conducted a survey of the embedded systems industry. A total of 1,703 survey responses from active, professional embedded system designers were received from engineers having an average of over 16 years of paid experience. Respondents were employed in companies of all sizes, about half within and half outside of North America, and across a broad range of vertical markets.

After carefully analyzing the response data, Barr Group's key findings regarding the current state of safety and security practices of embedded systems designers are:

- **There is a large opportunity to easily improve the safety of embedded systems by more broadly using well-known software development best practices.**
- **Broader use of software development best practices is also an opportunity to better secure the vast numbers of Internet-connected devices to come.**
- **About 1 in 6 designers of potentially injurious, Internet-connected embedded systems are completely ignoring security.**
- **Because the range of architectures and applications is large, there will never be a one-size-fits-all solution to the problem of securing embedded systems.**

In brief, there are potentially deadly embedded systems that are not designed with appropriate levels of care as well as systems that could be more secure. There is, thus, much work to be done in the embedded systems design community to achieve a safer and more secure world. Fortunately, a lot of what needs to be done is well understood and easy to implement; what appears to be lacking is motivation.

About Barr Group

Founded by internationally known experts in the design of safe and secure embedded systems, Barr Group is an independent provider of world-class consulting, training, and product design services. From pacemakers to cars, The Embedded Systems Experts[1] at Barr Group help make the computers inside everything safer, more reliable, and more secure.

As part of its mission to improve the whole industry, Barr Group conducts the *Embedded Systems Safety & Security Survey*™. With the highest response rate of any survey in the industry, this annual survey of the engineers who are on the front lines in the design of products that will soon come to market in a range of industries provides valuable insight into design trends and development practices.

Consistent with this mission, the Barr Group website is replete with how-to technical articles and other free resources for embedded systems designers. The company also produces free webinars on various topics, which can be attended live and also made available for later playback from its website.

In terms of its business, Barr Group specializes in providing unbiased embedded systems design process and (re)architecture consulting services to directors of engineering, technical managers, and the teams they lead. Many types of engagements are possible and each consultant is a senior engineering expert who communicates clearly and effectively in writing and in person. More information about Barr Group's consulting services can be found at http://www.barrgroup.com.

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[1] Barr Group, the Barr Group logo, and The Embedded Systems Experts are registered trademarks.

Barr Group also trains engineers and its world-class courses are designed to strengthen critical programming and engineering skills for embedded system design teams across all industries. Through these courses—such as the four-day, hands-on *Embedded Software Boot Camp*® and *Embedded Security Boot Camp*®—engineers learn the important development skills needed to cost-effectively design safer, more reliable, and more secure products. Barr Group offers public training in North America and Europe, as well as private and custom training courses all over the world.

Because Barr Group's engineers are independent-minded experts capable of researching tough subjects and adept at explaining complex technical topics in everyday language, Barr Group consultants have often been called upon to testify as expert witnesses in patent infringement, intellectual property, product liability, and other technical legal disputes. Notable expert testimony from Barr Group experts has related to the security of satellite communications systems and smartcards, smartphone industry patents, software copyrights in video games and multi-function printers, as well as the Toyota unintended acceleration personal injury litigation.

Finally, Barr Group's *Embedded C Coding Standard*™ has been adopted and adapted by thousands of embedded programmers and teams. The coding standard was created to help developers minimize bugs in firmware by focusing on practical rules that keep bugs out—while also improving the maintainability and portability of C/C++ code. Published as a print and electronic book as well as on the Barr Group website and fully compatible with MISRA's "Guidelines for the Use of the C Language in Critical Systems" subset of the language, the *Embedded C Coding Standard* details a set of guiding principles, naming conventions, and stylistic rules for the use of data types, functions, preprocessor macros, variables and much more. The individual rules that have been demonstrated to reduce or eliminate certain types of bugs are highlighted.

Background and Methodology

Barr Group's annual *Embedded Systems Safety & Security Survey* is a web browser-based online survey. The survey is designed to be easy to answer and to require only about 5-7 minutes to complete. This year's survey consisted of 36 multiple-choice questions and was hosted at SurveyMonkey.com.[2]

Outreach and Response

This year's survey was open from January 8, 2018 until January 31, 2018. After final editing and internal testing of the skip-logic, a 1-day "beta test" was performed via a soft launch of the survey on the Barr Group website and some social media channels. No problems were identified with the survey during the beta test and the survey was more broadly announced from the following day.

We subsequently leveraged the Barr Group mailing list in combination with other mailing lists for embedded systems designers to send approximately 220,000 total emails containing invitations to the survey. In addition, we announced the survey and provided links on our website at barrgroup.com, in social media (specifically, LinkedIn, Twitter, and Facebook), and in a blog post on embeddedgurus.com.

[2] Each of the questions and its possible answer choices is provided for reference in Appendix A. The full set of response data collected from the qualified respondents is provided in Appendix B.

As an incentive to participate as well as a thank you for their valuable time, those who completed the survey and also provided their email address were each given a chance to win one of two Fluke 117 digital multimeters (retail cost $179) or one of three Amazon.com gift cards ($25 value). An email address was not required to complete the survey and it was also possible to skip the survey just to enter to win a prize.

This year's survey results are drawn from 2,146 completed survey responses.[3] This number is lower than the number of people who followed a link to the survey and began to take it, as sometimes the respondent to a web-based survey will become distracted or fail to answer all of the questions for other reasons.[4]

Also excluded from the number above were survey responses deemed to be from "retakers" and "bots". The former were submitted by the same person and the latter by algorithm.[5] In the case of retakers, only the first (by date and time) completed response was retained.[6] Responses believed to be from bots were deleted from the database.

[3] An individual survey response was considered completed if all of the "required to answer" questions presented to that person (based on skip-logic) were answered.

[4] A review of this year's full database by IP address indicated that a large number of incomplete responses may be from people who later return to start again and complete the survey.

[5] Although the survey platform attempted to restrict multiple responses from the same IP address, some people could have taken the survey via distinct invitations received via distinct mailing lists.

[6] Brief scans of suspected pairs revealed that the answers to various questions were typically identical.

About 20% of the 2,146 completed survey responses were not from professional embedded systems design engineers.[7] For example, some were responses from students, professors or other teachers or researchers, or company executives who are not directly involved in the design of any specific product.[8]

To improve the quality of the data and analysis, skip logic embedded in the flow of survey questions was used to narrow the group that answered the more detailed questions. For example, respondents who answered the question "*How much professional experience (paid work, not counting academic work) do you have in the field of embedded systems design*?" with "*I have no professional experience in embedded systems design*." were rerouted to the demographic questions near the end.

This technique reduced the dataset in the following manner:

- 158 respondents had already participated or just hoped to win a prize;
- 115 respondents had never been paid to design embedded systems;
- 104 respondents were not directly involved in software or hardware design; and
- 66 respondents were unable to adequately identify a current project.[9]

The remaining set of 1,703 qualified survey responses is believed to be entirely from paid/professional embedded systems designers who are actively working on an identifiable design project. The data and analysis presented in this report is drawn only from this subset.

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[7] Though the majority of the non-qualified respondents may have tangential connections to the embedded systems industry, analyzing this data would have made the overall findings less accurate.

[8] All respondents who provided an email address were given an equal chance in the prize drawings.

[9] Or were designing a tool to assist embedded systems designers in their work rather than an end product that is itself an embedded system.

Statistical Significance

With its sample size of 1,703, this survey is mathematically calculated to have a confidence interval of +/- 2.4% at a confidence level of 95%.[10] More simply put, the true percentage across all professional embedded systems designers is 95% likely to lie within +/- 2.4% of the measured sample. For example, if 60% of those surveyed have adopted a coding standard, the actual percentage is almost certainly between 57.6% and 62.4%.

Note, however, that the surveyed group of 1,703 designers may not qualify as a randomly-selected group of the overall universe of professional embedded systems designers. That is, there are probably biases inherent in the methods of the invitation process, such as using English to communicate as well as certain mailing lists. Likewise, there may be certain subgroups within those invited who are more likely to open industry emails and/or participate in online surveys.

In some sections, the survey data analyzed in this report is with respect to a subset of the responses. For example, several important subsets are:

- A subset of 482 who are designing potentially dangerous systems, with a confidence interval of +/- 4.5%.
- A subset of 244 who are designing potentially dangerous systems that will also be Internet-connected, with a confidence interval of +/- 6.3%.

[10] See, e.g., http://www.surveysystem.com/sscalc.htm

Respondent Demographics

Before presenting the detailed analysis of embedded system development processes and architectures, it is worthwhile to consider respondent demographics.

Where They Live

We sought and received survey participation from English-speaking embedded systems designers wherever they were in the world.[11] The worldwide distribution of qualified survey respondents was as shown in Figure 1. Compared with the reach of the prior year survey responses this year were more likely to be from Europe and less likely from North America or Asia.

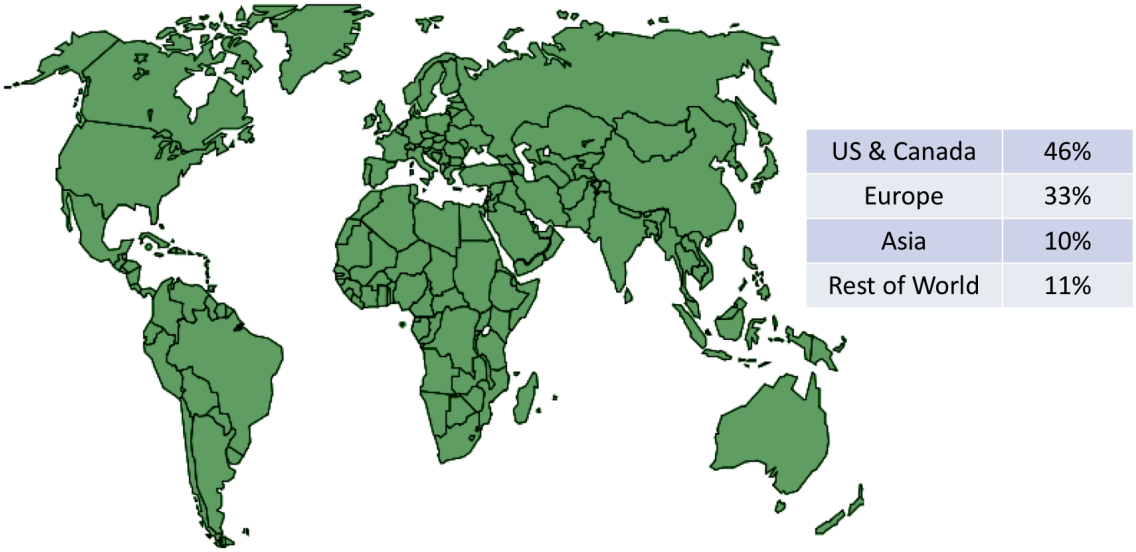

Figure 1. Worldwide Distribution of Surveyed Embedded Systems Designers

Roughly consistent with their relative population sizes, survey responses from Canada were again this year roughly one-ninth of the total from the U.S. & Canada.

[11] Design engineers who don't speak English and/or don't subscribe to industry news in English were likely missed.

What They've Done

Although the largest percentage (36%) of qualified survey respondents were still in a group in the first decade of paid embedded systems design experience, the average respondent had a long design career spanning already over 16 years.[12] As also shown in Figure 2, the average number of years of paid experience was much higher in the United States (20 years) than either Europe (14) or Asia (10).

Notably, the experience distribution in the U.S. is effectively flat, with 23% of designers having more than 30 years of professional experience and each decade having from 23% to 28% of the overall. Together this data suggests an aging of American embedded systems designers combined with lesser interest and/or fewer opportunities for entry-level engineers in what is obviously a growing industry worldwide.

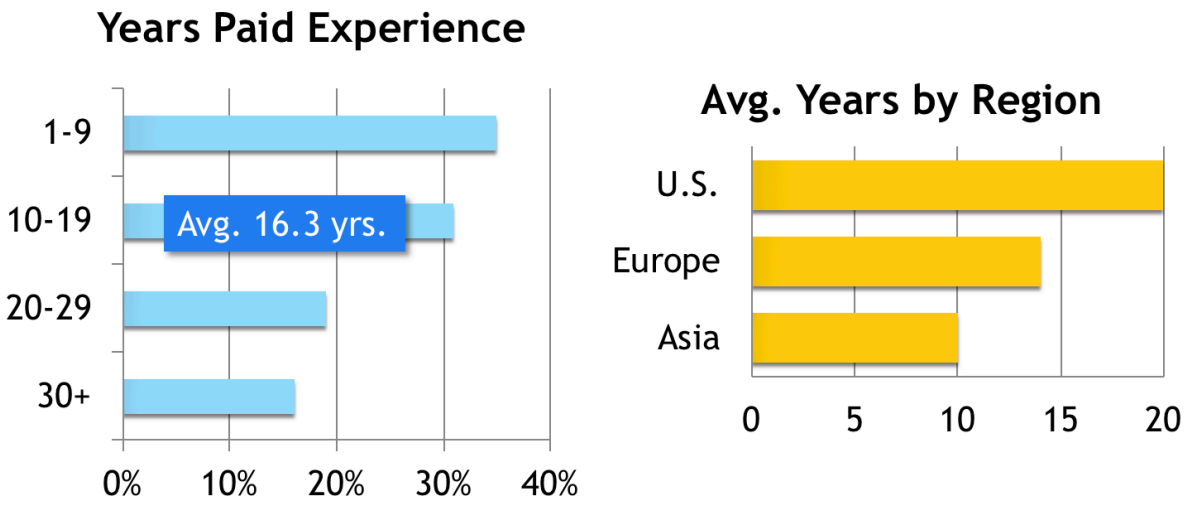

Figure 2. Years of Professional Embedded Systems Design Experience

[12] Averages were computed as the weighted average of the midpoints of each answer group (i.e., 5 years was used for the 1-9 group, 15 years for 10-19, 25 for 20-29, and 35 for 30+).

Where They Work

Embedded systems are products destined for a wide-range of vertical markets. Some will become subsystems in a complex product, such as an automobile or a fighter jet; some may be one-a-kind and travel to distant worlds. Others are simple standalone children's toys. Respondents to this year's survey indicated that their current projects were targeting a diverse range of industries, as shown in Figure 3.

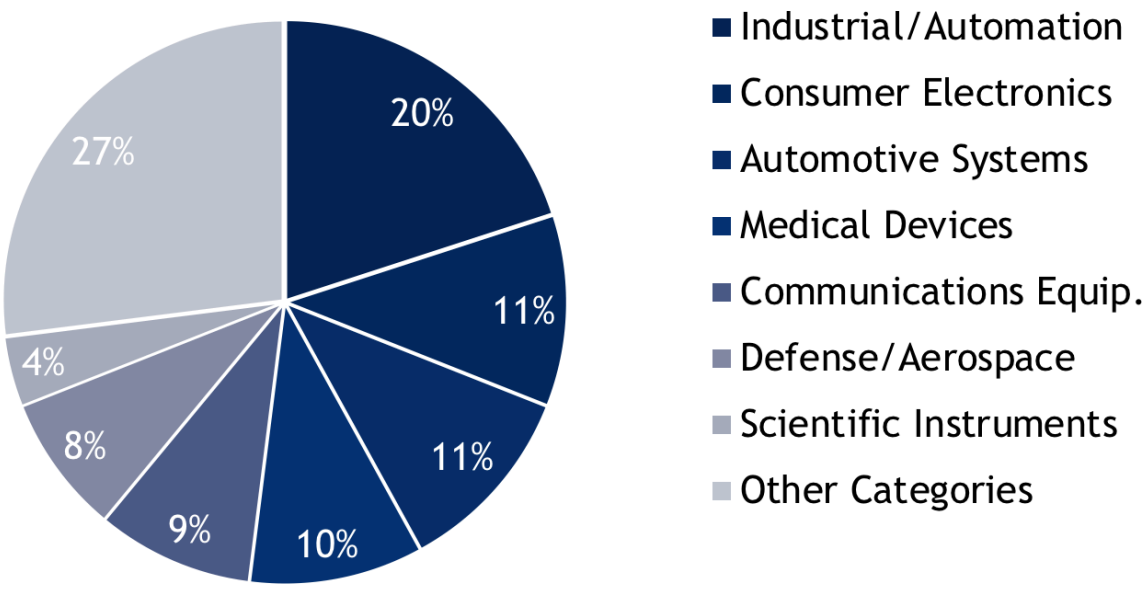

Figure 3. Vertical Markets Currently Targeted by Survey Respondents

Figure 4 presents data concerning the size of the organizations studied. The survey results represent a broad sample of the design practices of companies in a range of sizes, from the tiniest startups to the very largest multi-nationals.

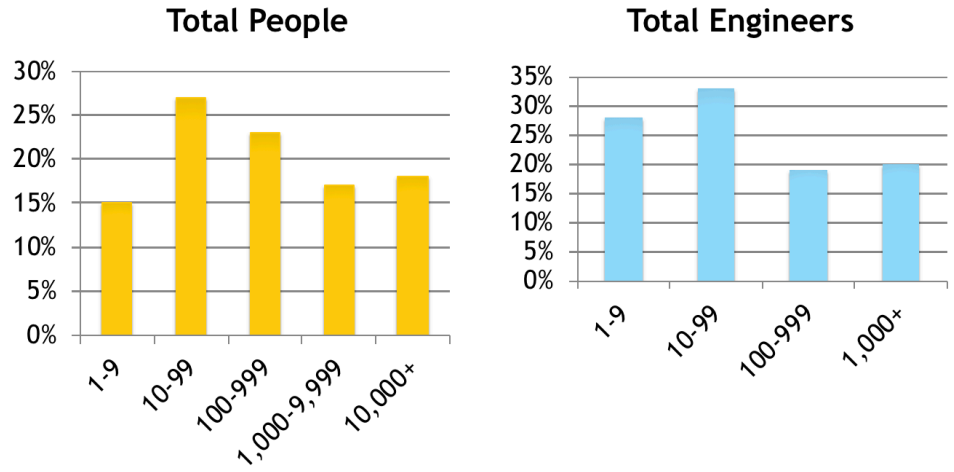

Figure 4. Sizes of the Organizations from Which Respondents Participated

Once again this year, a broad range of companies was represented. A sampling of the organizations from which embedded systems designers participated is shown in Figure 5. This is merely a sample and does not include the names of numerous other companies and organizations.

ABB * Aclara * Adtran * Amazon * Ametek * **Apple** * Applied Cardiac Systems
Aquatron Robotics * Battelle * **Bayer Healthcare** * Belkin * BorgWarner * **Bosch**
Bose * Carrier * CERN * **Cisco** * Continental Automotive * Danfoss * Dolby
Dynon Avionics * **Dyson** * Eaton * Emerson * **Fiat Chrysler** * Fluke * **Ford Motor**
GE Healthcare * Harman * Harris * **Honeywell** * IBM * Intel * **iRobot** * JHU-APL
John Deere * Keysight * L-3 * **Lear** * Lockheed Martin * **Medtronic** * Motorola
NASA * Nokia * Nike * Northrup Grumman * Omron * Osram * **Otis Elevator**
Panasonic * **Philips Respironics** * **Pitney Bowes** * Plantronics * Plexus
Qualcomm * Renesas * Rockwell Automation * Rockwell Collins * **Saab** * Sandisk
Schneider Electric * Schonstedt * Sciex * **Seagate** * Sharp * Signetic * **Starkey**
Steinway * Tata Elxsi * Teledyne * Thales * Thermo Fisher * Texas Instruments
ThyssenKrupp * Tyco * Valeo * Visteon * **Volvo** * Wavetronix * **Zebra**

Figure 5. Some of the Many Organizations Represented in This Year's Survey

What They Do

By definition, the design of an embedded system involves the design of both electronics (i.e., "hardware") and associated embedded software (a.k.a., "firmware"). On smaller projects, a single engineer may do both. On larger projects, a team of hardware designers, firmware developers, and testers work together. Typically, the software subgroup is the largest and includes also hardware-software dualists.

Figure 6 shows the distribution of the sizes of software-development teams, during the period of peak effort. Importantly, about two-thirds of software teams never have more than 4 people and only about 17% ever have 10 or more people. Figure 6 also shows the primary roles of those who responded to the survey.[13] The largest group (56%) primarily develops software. The second largest group (20%) regularly develops both software and hardware. Those who develop primarily hardware amount for a small subset (7%) of those surveyed. Nearly all of the other respondents were hands-on technical managers or system-level architects.

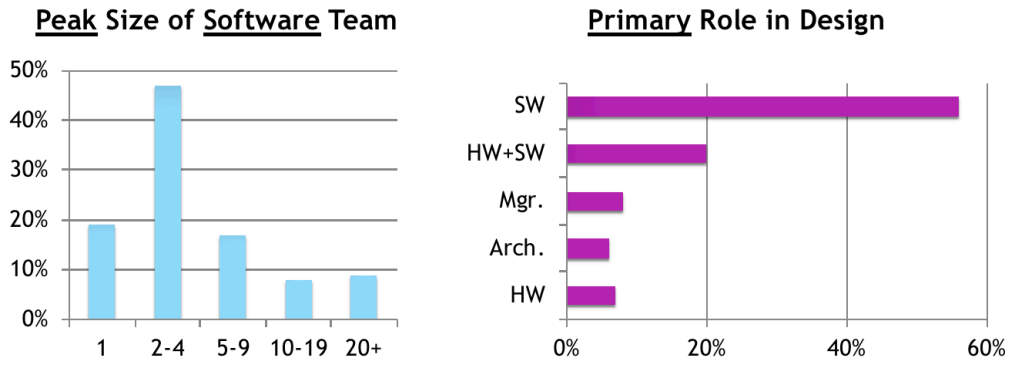

Figure 6. Peak Software Development Team Size and Respondent Primary Roles

[13] As mentioned above, we disqualified survey takers who indicated they worked in academia and those in executive management roles.

Industry Snapshot

Nearly all of the survey questions were asked in the context of a "*single embedded systems design project you are currently involved with.*" Reminders of this context were placed at the top of each of the technical parts of the survey. As well, the phrase "*your current project*" was made part of the phrasing of questions to aid clarity.[14]

Processors

Over the last decade the number of processors (including microcontrollers and cores) in a typical embedded system has grown substantially, as can be seen in Figure 7. Less than a third of new designs have a single processor. At the other extreme, more than a quarter have four or more processors. The largest group now have either 2 or 3 processors. And the trend toward 4 or more processors appears to be accelerating.

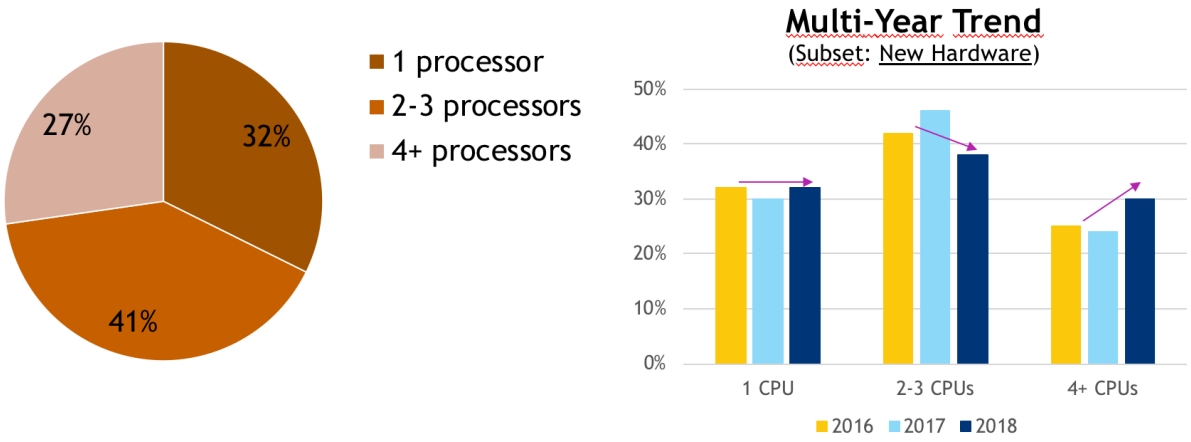

Figure 7. Number of Processors in Current Embedded Systems Designs

[14] Because—even with reminders like these—humans are not always reliable/consistent, we took the added step of disqualifying a few dozen of the respondents who answered "I don't know" to certain base-lining questions.

Operating Systems

In our experience, it is most commonly the case in multi-CPU designs that there is one primary processor that may run some type of commercial or open-source operating system and this is then surrounded by either cores or microcontrollers that are much more likely to have no formal operating system. Rather than try to get at all of these details, which would be difficult in a multiple-choice survey, we asked very directly about the type of operating system on the "primary processor." Figure 8 shows the results.

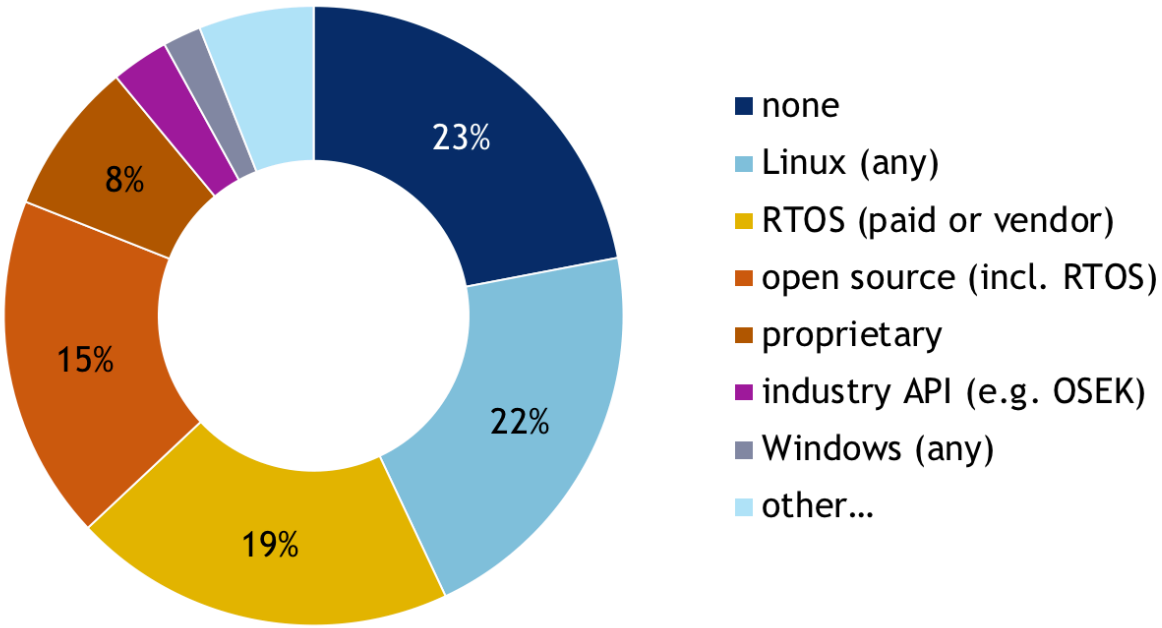

Figure 8. Type of Operating System on Primary Processor

Interestingly—even on the primary processor—the most popular type of operating system was "no operating system." The most popular category of actual operating system is now Linux, which is a change from prior years when "RTOS" (an aggregate of those paying for a commercial RTOS and those provided an operating system from their chip vendor, which now ranks third) was the most used. Following ever more closely on the heels of those "commercial" RTOSes are the open source operating systems (e.g., FreeRTOS) that lack licensing fees. Adding "proprietary" (i.e., company-internal) operating systems to the above brings the percentage of all designs covered by these top choices to 89%. A bit of Windows, Android, and state machine frameworks completes the list.

We can get some sense of the range in the architecture of embedded systems by comparing the rankings of the five most popular operating system choices based on the number of processors. As shown in Table 1, the percentage of designers writing their own "proprietary" operating system is about the same (7-9%) regardless of processor count. But Linux clearly becomes a much more popular choice (climbs from 11% to 32%) as the number of processors increases, while "open source" and "no operating system" drop in popularity.

1 processor	2-3 processors	4+ processors
none (37%)	Linux (22%)	Linux (32%)
open source (21%)	RTOS (20%)	RTOS (26%)
RTOS (13%)	none (20%)	open source (13%)
Linux (11%)	open source (19%)	none (10%)
proprietary (9%)	proprietary (9%)	proprietary (7%)

Table 1. Primary Operating System Choices by Number of Processors

Compared with last year, use of RTOSes is down substantially on single-processor designs: from 18% to 13% with open source taking over second place. And on 2-3 processors designs, RTOS use is down from 24% to 20% and Linux leapt into first place with a gain of share from 17% to 24%. Most choices are stable on 4+ processor designs, except that open source climbed from 9% to 13% to take over third place. Use of proprietary kernels remained in fifth place.

Two decades ago, the trend was away from custom-written proprietary kernels toward commercial RTOSes typically licensed with a per unit royalty. From 1997 until their merger in 2000, Wind River and Integrated System together dominated this part of the market. According to surveys taken at the time, either VxWorks or pSOS was the operating system of choice for about 1 in 4 new embedded systems designs.[15]

At the turn of the century, the market was divided roughly as follows: 39% no operating system, 31% commercial RTOS, 18% proprietary kernel, and 12% Linux. Since that time, the selection of operating systems by embedded systems designers has changed considerably. Figure 9 shows the long-term trend in operating system type.

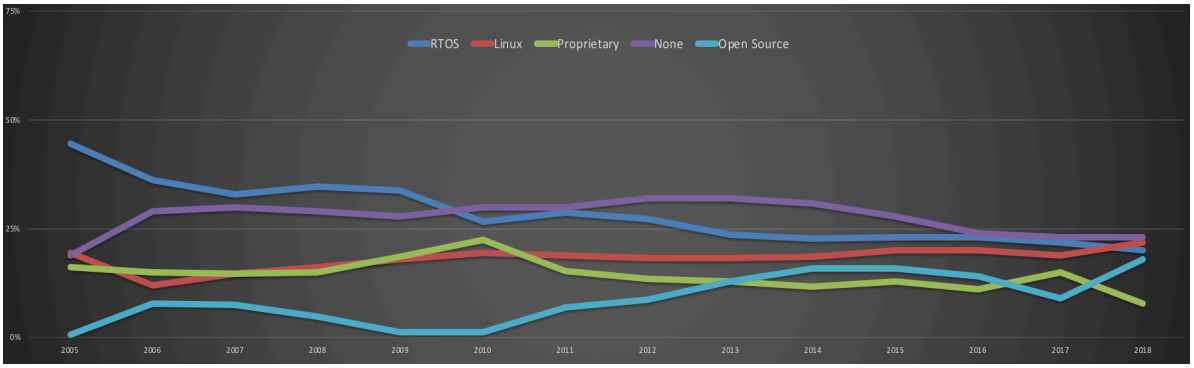

Figure 9. Long-Term Trends in Embedded Operating System Selection

[15] Survey data prior to 2015 is from the formerly annual surveys taken by publishers of the magazine *Embedded Systems Programming* and affiliated website Embedded.com.

As the data shows, there are still quite a few designs that run "no operating system" on their primary processor; especially in single processor designs. However, this architecture is down substantially overall from 39% to just 22%. Use of proprietary operating systems is also down about half over the same period, from 18% to just 8%. Linux has moved up to become the most popular overall category of operating system. And following ever more closely on the heels of those RTOSes are the other open source choices (e.g., FreeRTOS) that, like many variants of Linux, lack licensing fees.

Internet/Connectivity

As shown in Figure 10, the percentage of embedded systems designs that were expected to be always or sometimes connected (directly or indirectly) to the Internet was remarkably high, at 61%.[16] The means of connection to other computers was indicated to be predominantly via wired and wireless network interfaces. However, slightly over 50% of Internet-connected designs had at least one wired direct interface.

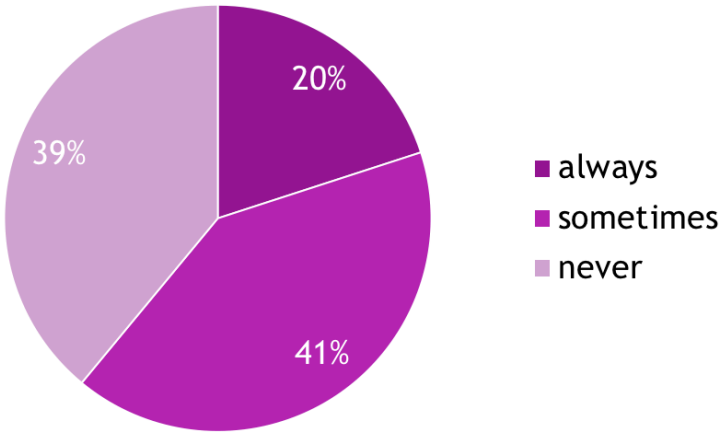

Figure 10. Frequency of Internet Connections

Of respondents designing Internet-connected products, 39% said users of the product would be able to interact with it via a Web browser and 46% (not always the same respondents) said there would be an associated App (such as for iOS or Android). There was a big leap toward more use of Apps here, which was up from 39% in 2017.

[16] The percentage here reflects the weighted re-treatment of a small number (3% or 52) of "I don't know." responses into the three other categories. In so doing, we presume the design of these particular systems was in an earlier stage than others but that about the same percentages of "Always," "Sometimes," or "Never" responses would eventually apply. Without this, the "Always" + "Sometimes" total is 60% rather than 62% (and the total in the associated figure would be 97%). Elsewhere, the set of "Internet-connected" designs analyzed in this report omits these "don't know" respondents (since it is not clear which specifically would be connected).

Programming Languages

It's typically the case that multiple programming languages are used on a single project. For example, nearly every design will require at least one engineer to write at least a little bit of assembly language code. The trend toward multiple processors likely exacerbates the use of multiple languages as, for example, the primary processor might run Linux with applications written in Java or C++ while a sea of microcontrollers supporting it might each be coded entirely in C.

We sought some clarity by asking a straightforward question about the one "primary" programming language on their current project. As shown in Figure 11, almost 95% of embedded programmers wrote the majority of their code in either C or C++. Every other programming language was in the noise, near or below 1%.

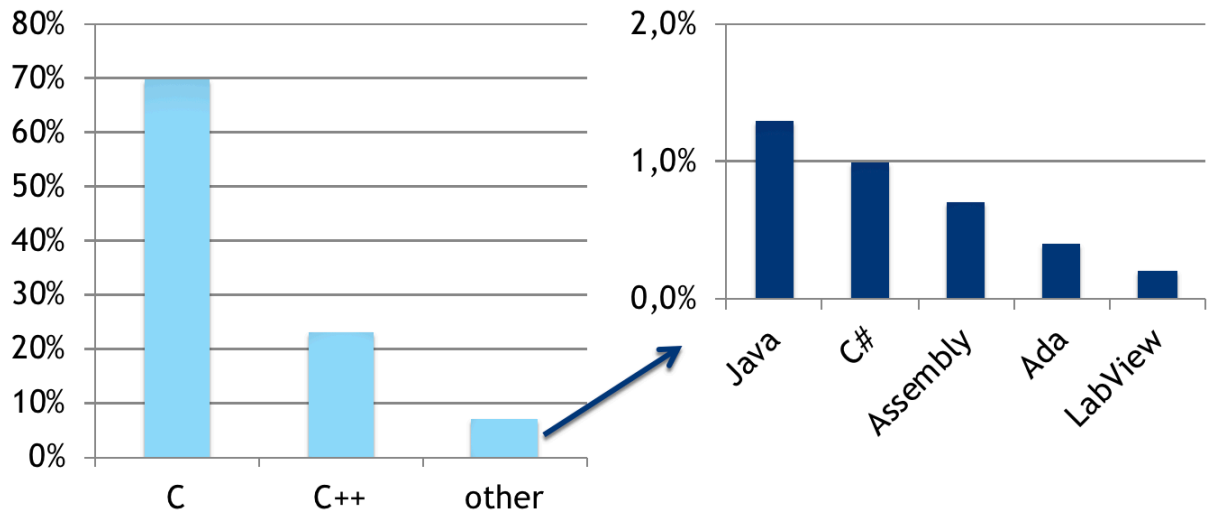

Figure 11. Primary Programming Language in Embedded Systems Designs

Note that C++ stole some share from C as the number of processors increased, with 33% of respondents designing a system with 4 or more processors indicating that C++ was the primary language—vs. just 16% in single-processor designs. That said, there is no apparent multi-year trend of C++ stealing share from C across the board.

A longitudinal study of survey data spanning almost a decade and a half shows that C remains the primary programming language of embedded software. Remarkably, in that time C has actually gained market share from 50% to about 70%–at the expense of assembly, C++, and Java.

Figure 12 shows the relevant data from 2005 through 2018. The first decade of this data is drawn from annual surveys by the publishers of Embedded Systems Design magazine and Embedded.com. The more recent data comes from prior years of Barr Group's survey. Each of these surveys of embedded systems designers phrased the relevant question similarly, either "*My current embedded project is programmed mostly in* [pick one]" (Embedded.com) or "*What is the primary programming language for your current project?* [pick one]" (Barr Group).

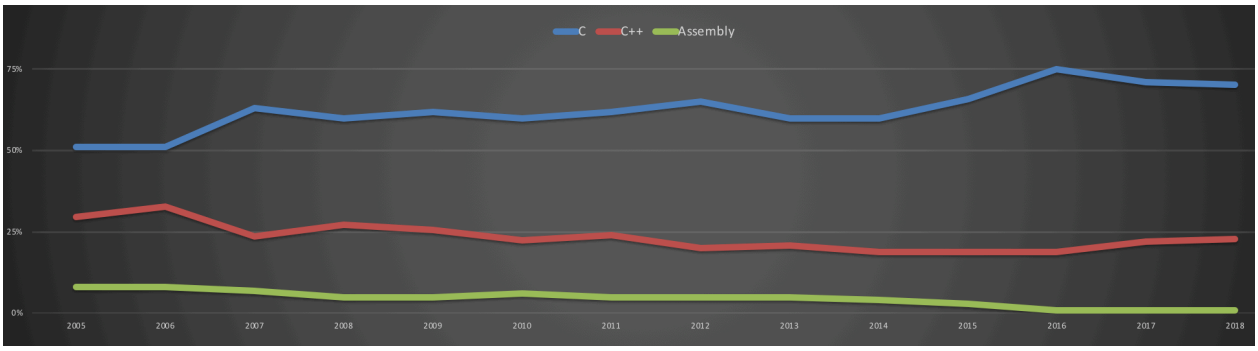

Figure 12. Long-Term Primary Programming Language Trends

It makes sense that the use of assembly as a primary programming language would be falling. Of course, there will always be some low level code that needs to be written in the native language of the machine–if only to bring up the higher-level language execution and for drivers and kernel code. But with inexpensive 32-bit microcontrollers increasingly at the heart of embedded systems there's no sense wasting time writing application code in assembly. We can attribute about 7 percentage points of the growth in use of C to the reduction in use of assembly during these years. This trend has helped use of C grow to about 60%.

But what's also been happening in this time is that C++ has failed to capitalize on earlier gains. The peak year for C++ use was apparently 2006, when it had a 33% share. Use of C++ as the primary language has since fallen and thus added about 10 percentage points to use of C. Data for Java is not included in the long-term graph, but its use has been less common than assembly in most survey years, with high points of 3% and now down to around 1% the last three years. And no other language has emerged to maintain greater than about a 1% share.

For now and the foreseeable future, C remains the most cost-effective way to write embedded software. In hindsight, object-oriented languages have been tried but failed to establish their value in the embedded programming space. C++ is a player but looks unlikely to ever eclipse its namesake.

Software Development Processes

Figure 13 and Figure 14 show the percentage use of a set of well-known software development process steps within the embedded systems design community. Relative to the 2017 survey results, the only statistically significant changes are with respect to use of version control (up 3 percentage points) and TDD (down 8 points).

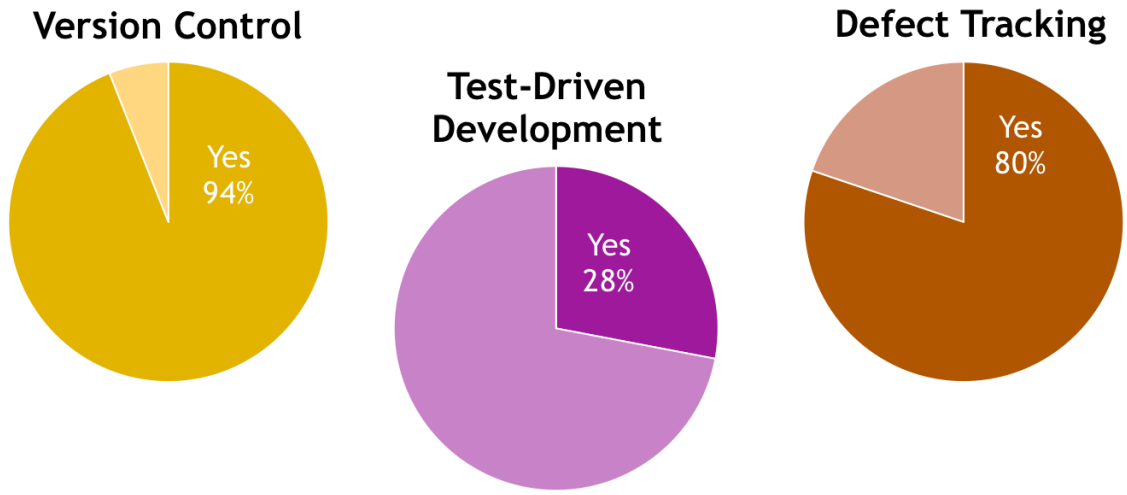

Figure 13. Percentage Use of Version Control, TDD, and Defect Tracking

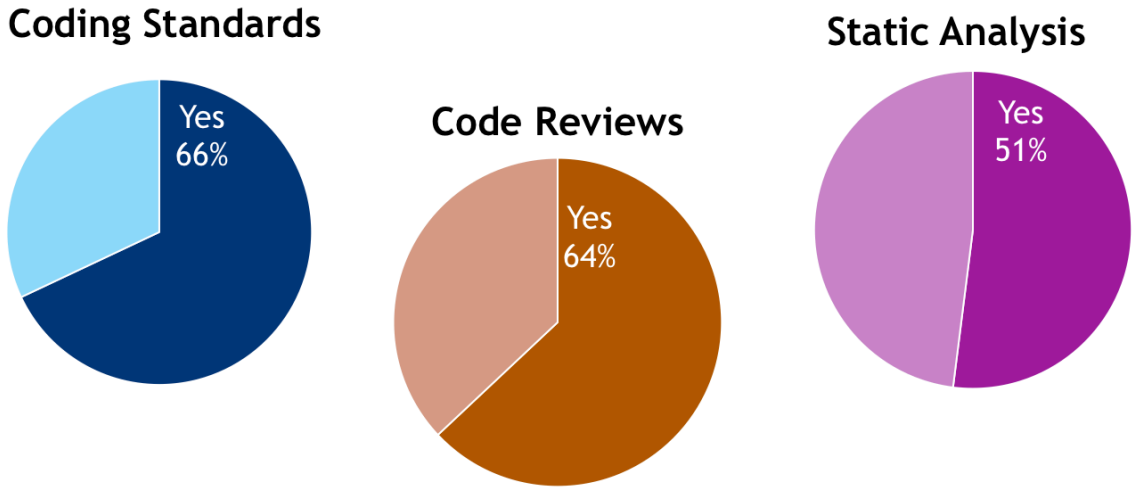

Figure 14. Percentage Use of Coding Standards, Code Reviews, and Static Analysis

With respect to coding standards, there are some positive trends to report. This year a higher percentage of respondents said that they had a written coding standard that applied to their current project. As well, a higher percentage of those with written standards appeared to have migrated from a proprietary standard toward a standard designed from the ground up to reduce the number of bugs finding their way into the source code. The data is shown in Figure 15.

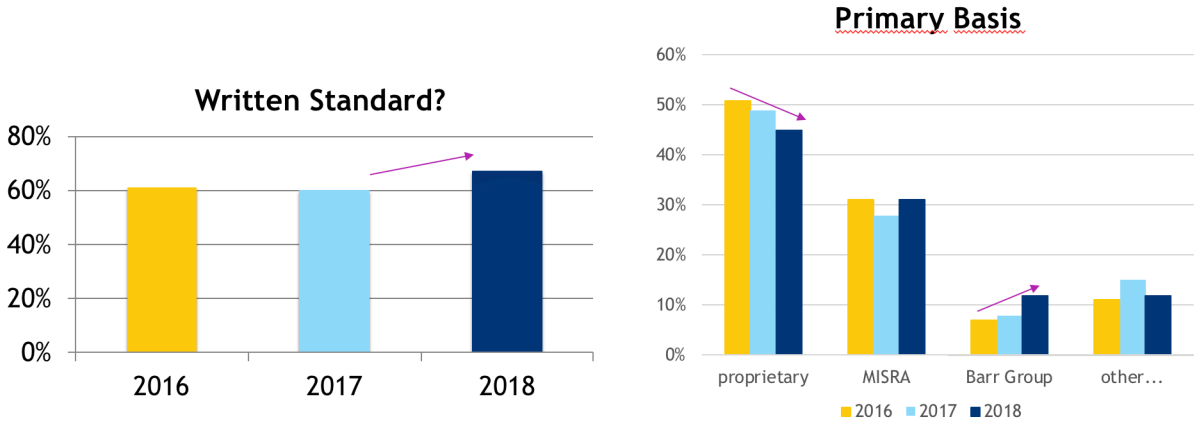

Figure 15. Trends in Coding Standards Use

One explanation for the increasing adherence to Barr Group's *Embedded C Coding Standard* is that this set of rules, which was developed from the ground up to help keep bugs out of embedded software and thereby reduce time spent in the debug phase of a project, is now free. The full contents of the book are available in free PDF download and HTML online versions at http://barrgroup.com/coding-standard. As well, an editable Microsoft Word version is available for license by teams that want to customize the rules to their project.

The MISRA-C and Barr Group standards do not compete. Rather they define compatible and complementary rule sets. MISRA defines a subset of the C language that is safer than the whole whereas the Barr Group coding standard includes a few overlapping rules and adds others that are more stylistic than MISRA.

Safety Analysis

The first issue to note about safety is the relatively high percentage (29%) of embedded system designers are building a product that could—in the worst case—kill or injure one or more people. This and related data is broken down in Figure 16.

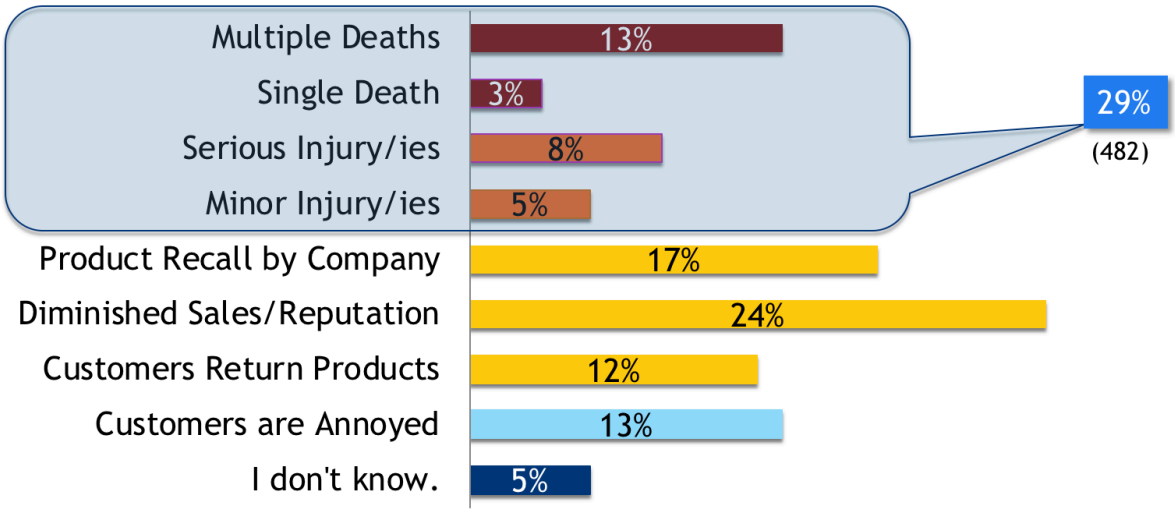

Figure 16. Worst-Case Possible Outcome in the Event of a Malfunction

We now analyze the survey data from the subset of professional embedded systems designers who could potentially end up with blood on their hands. More than two thirds of these potentially dangerous products are designed primarily for use in one of four industries:

- Medical Devices
- Industrial Controls
- Automotive Systems
- Defense/Aerospace

Safety-Related Practices

Coding Standards

Some good news is that compared with all embedded systems designers, the subgroup that is designing potentially dangerous products was more likely to have a written coding standard that applies to their product. Unfortunately, however, far too many (17%) dangerous systems designers work on projects lacking a coding standard.

Fewer than half of the coding standards that are in place for potentially injurious products are based on standards specifically written to promote safer systems: i.e., those originating from the MISRA, Barr Group, High Integrity, or JSF standards for C or C++. In our many years of collective experience as consultants we have found that proprietary coding standards are generally ad-hoc documents not written with safer programming practices first of mind.

Furthermore, as shown in Figure 17, enforcement of coding standards is too lax.

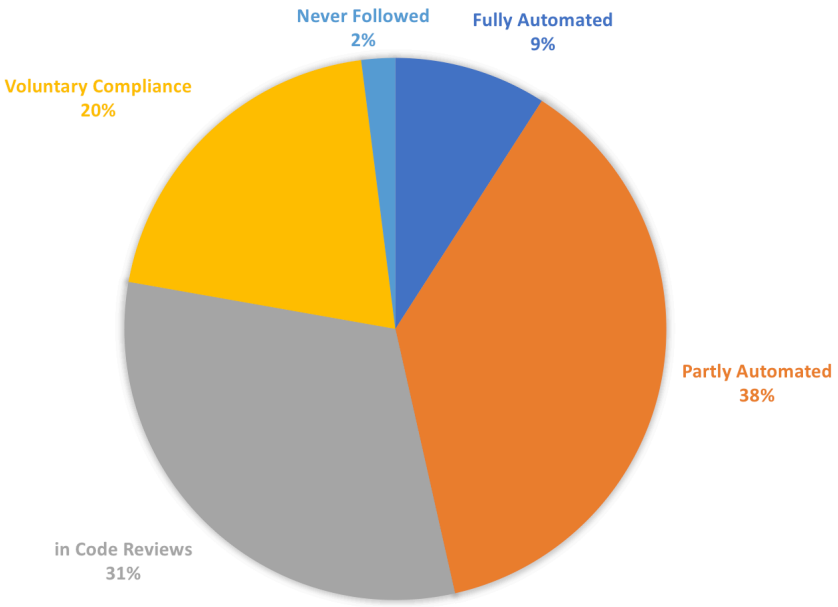

Figure 17. Enforcement of Coding Standards in Safety-Critical Products

Defect Tracking

Incredibly, 12% of respondents designing products that could kill or injure one or more people did not have any formal process or system in place to track known defects in their design. This is irresponsible behavior. No reasonably complex system can be completely free of bugs and defect-tracking need not be more difficult to setup than a spreadsheet or small database.

Static Analysis

Static analysis tools are software programs that automate the process of scanning source code for potential bugs as well as violations of best practices. One of the most widely used of these tools, called PC/Lint, costs just a few hundred dollars to purchase. In addition to alerting programmers to potential problems in a repeatable and impartial way, static analysis tools can also be used to automate enforcement of many of the rules in coding standards.

Overall, slightly more than half of survey respondents indicated that their project's source code is run through one or more static analysis tools. Some good news was that the subgroup that is designing potentially injurious products was more likely to use static analysis than the whole. Unfortunately, 33% of designers of potentially injurious products report not using static analysis at all. This is obviously a huge issue: users of these products could be killed or injured by bugs that could have been easily and inexpensively flagged by static analysis.

Figure 18 breaks down the non-use of static analysis tools according to worst-case risk. Ideally this curve would not only trend downward to the right (as it does), but also reach 0% at or before the "one death" column. It is downright scary that about a quarter of the embedded systems that could kill are being programmed without static analysis as a step in the software development process.

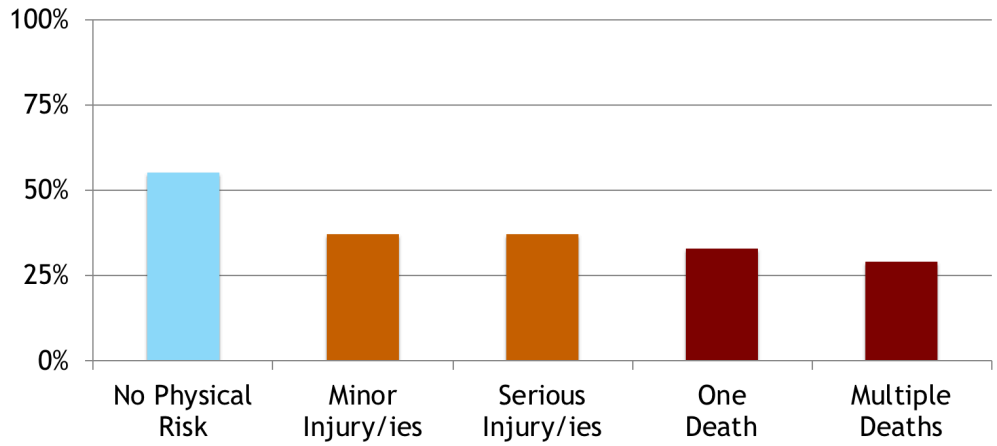

Figure 18. Percentage Non-Use of Static Analysis by Safety Risk Category

Code Reviews

Overall, 57% of the designers of potentially injurious products said peer code reviews were either a regular process step or that pair programming was used on their current project. That's great news, as code reviews are well known to be one of the most cost-effective techniques for finding and fixing bugs in software.

Unfortunately, though, 28% of the developers of these products said they rarely, if ever, perform code reviews in any way! And another 17% said they only perform code reviews for some modules or when problems arise. Here again people could be killed or injured by bugs that might have been easily spotted in a code review.

Safety Standards

There are a variety of industry-specific and general safety standards, such as MISRA's *Development Guidelines for Vehicle Based Software* and ISO-26262 for the automotive industry or the more broadly applicable IEC 60602 and IEC 61508. Broadly speaking, such safety standards and guidelines describe relevant best practices for designing safer systems as well as procedures for documenting when and how the practices were performed.[17]

One of the surprises in the survey data was that a large number of the designers of safety-critical systems (38%) are not following any relevant safety standard. Of those conforming to accepted safety standards, the most common standards followed are (starting with the most widely followed):

- MISRA
- ISO-26262
- IEC 60601
- IEC 62304
- IEC 61508
- DO-178 / DO-254
- FDA 510(k)

In some cases, such as with the U.S. FDA's 510(k) guidelines for medical devices, products containing electronics and software cannot be legally sold in a country or region unless the developers conform to the norms of a specific safety standard.

[17] The principle is similar to ISO-9001 in manufacturing: repeatable processes, properly executed, drive up consistency of outcomes. However, the design of electronics and software is quite different from the manufacture of widgets in a factory and that is why these more specialized safety standards exist.

Testing

Testing of embedded systems takes many forms, from unit testing of individual software modules, to hardware-in-the-loop simulation that combines the full software on a hardware test-bed, and finally system-level testing of all of the components and their interactions. Of the available testing techniques, two are worthy of special mention in the context of safety-critical systems: test-driven development and regression testing.

Test-driven development (TDD) is a powerful technique for building reliable software that involves developing the test harness for each software module in parallel with writing the code that implements the actual functionality. A major benefit of TDD is that the library of test code grows as the product comes together and this testing code can be utilized to ensure that later changes in the functional code don't inadvertently break the system. As shown in Figure 19, less than a third of the designers of potentially dangerous embedded systems were employing TDD.

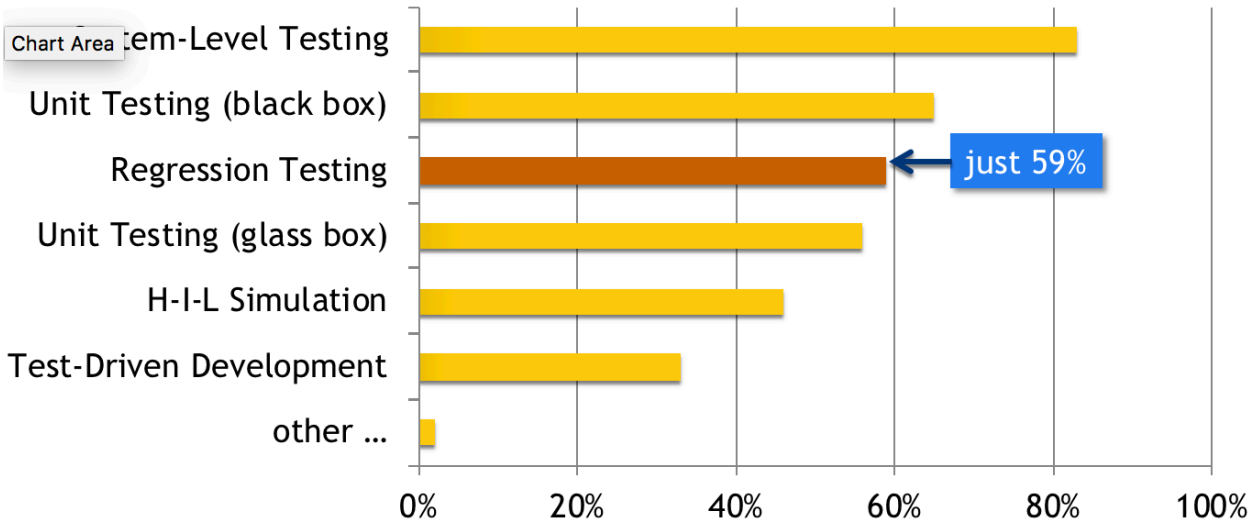

Figure 19. Types of Testing Performed on Safety-Critical Products

Regression testing is a powerful technique that generally ensures that the quality and reliability of a product can only increase over time (i.e., quality does not regress with software updates). In a nutshell, the method of regression testing is to develop a large library of tests and to then test each software upgrade by running all of the tests in the library.[18] Each time a bug is found and killed it is standard practice to add new regression tests to the library to detect that type of bug should it recur in any future version.

There is no other type of testing that can ensure a monotonic increase in quality. Therefore, regression testing is an important software development step to ensure there is no back-sliding in product safety. Thus it is concerning that only about 59% of the designers of embedded systems that could kill or injure people were using regression testing.

Findings

<u>There is a large opportunity to easily improve the safety of embedded systems by more broadly using well-known software development best practices.</u>

It is never sufficient to declare a system safe simply because certain processes and/or tools are used in the software development. There is much more to safety than process, including the architecture of the system. A team should also develop a formal written safety case to document the various design aspects that ensure that neither death nor injury can occur.

[18] This technique can be utilized in conjunction with the unit tests produced in the TDD process, though it does not require the use of TDD.

That said, certain best practice software development processes and tools are widely recommended and/or mandated by safety standards, including F.D.A. 510(k) guidelines for medical devices sold in the United States and the MISRA and ISO-26262 safety standards in the automotive industry.[19] And this is for a good reason: the use of processes such as coding standards, static analysis, and code reviews are—for example—well-studied, cost-effective techniques that can prevent and/or detect bugs before they are able to endanger product users.

This year's survey provides ample evidence that too many designers of safety-critical embedded systems continue either not to use some of these best practice process steps at all or aren't properly implementing those steps. Specifically, use of version control should be universal for all embedded systems designers. Likewise, keeping a database of known defects should be universal. The same is also true of use of static analysis tools and code reviews. And yet the failings of safety-critical system designers clearly go well beyond those to also include: not universally adopting or enforcing bug-killing coding standards; not universally setting up and using a testing system with quality-enhancing properties a la TDD and/or regression testing.

In some cases the failure of embedded systems designers to take these reasonable steps during development software may be indicative of engineering malpractice. As long as the current state of affairs persists, there will be many people utilizing and/or in the vicinity of unsafe devices and some of these people could be injured or killed by easily preventable or detectable bugs.

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[19] Many embedded software engineers are familiar with the MISRA-C coding guidelines. However, the same automotive safety organization earlier published a set of *Development Guidelines for Vehicle Based Software* of which the better known C and C++ coding guidelines are a mere accompanying detail.

Security Analysis

About two thirds (67%) of respondents said that security was a design requirement on their current project. That is up substantially from last year, when only 60% had security requirements. Figure 22 summarizes the data for this positive trend.

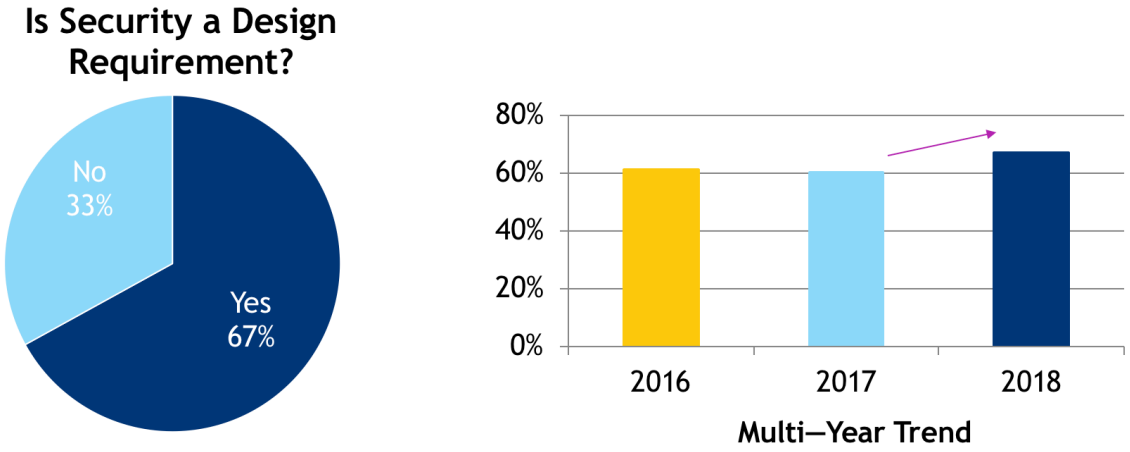


Figure 20. Percentage of Projects Having Security Requirements

Security-Related Practices

Primary Security Concerns

The 1,112 survey respondents who indicated there were design requirements relating to security on their project were asked to identify the one or more security concerns underlying these requirements. That is, what could go wrong if their device were successfully hacked. The results are shown in Figure 21.

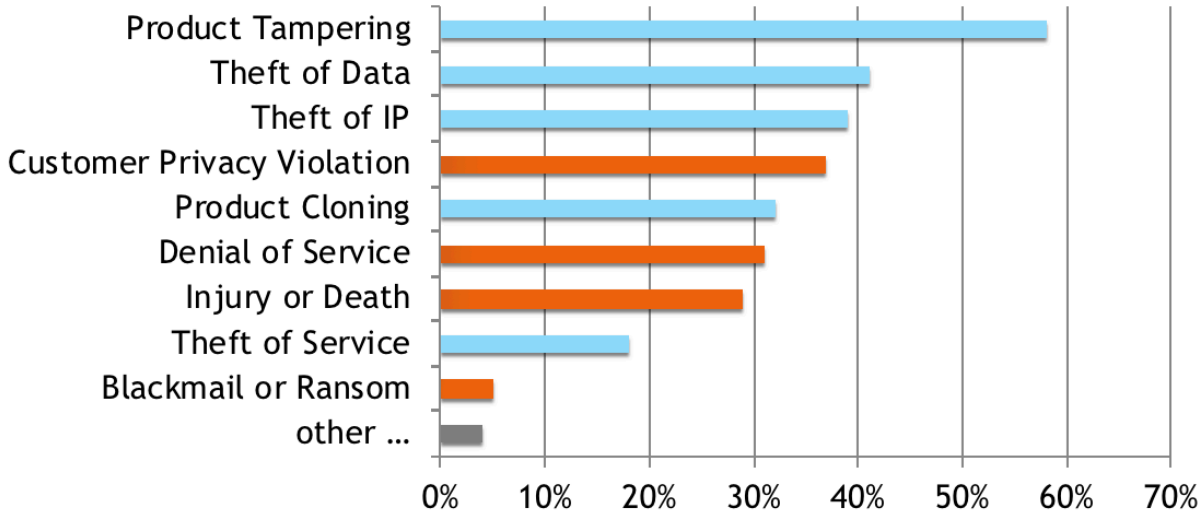


Figure 21. Ranking of Hacking Concerns of Products with Security Requirements

One interesting insight is that the highest-ranked security concerns were more likely to relate to the company that designed the product than to the users of the product. For example, a hacker who tampers with a product, steals the data or intellectual property of the company, or clones the product might be working for a competitor or otherwise able to undermine the money-making prospects of the device manufacturer. On the other hand, violations of customer privacy, denials of service, injury/death, and blackmail/ransom were lower-ranking concerns for the designers.

The one concern that is trending here is product tampering, which is up 6 percentage points from 52% to 58% in the last two years.

Security Layers

The survey also asked those respondents with security concerns to select all of the security-related technologies they were using to improve the security of their products. For example, encryption of communications between the device and other systems with which it will communicate. The results are shown in Figure 22.

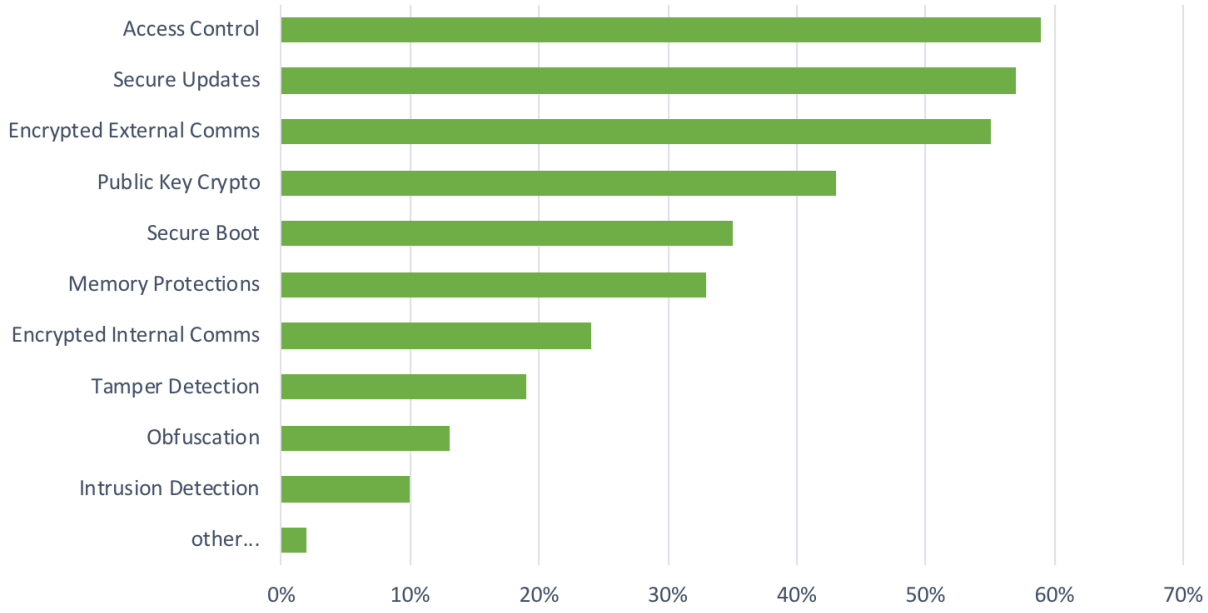


Figure 22. Percentage Use of Security-Related Technologies

Of these security-related technologies, use of both encrypted external communications and public key cryptography are up substantially in the last two years. The former from 50% to 55% and the latter from 32% to 43%.

Security-Related Processes

Finally, we asked designers of systems with security as a design requirement what process steps they were taking to better secure their products. This could include the aforementioned software development best practices, such as code reviews and static analysis, in addition to threat and vulnerability analysis techniques and active testing techniques, such as fuzzing and penetration testing. The responses are shown in Figure 23.

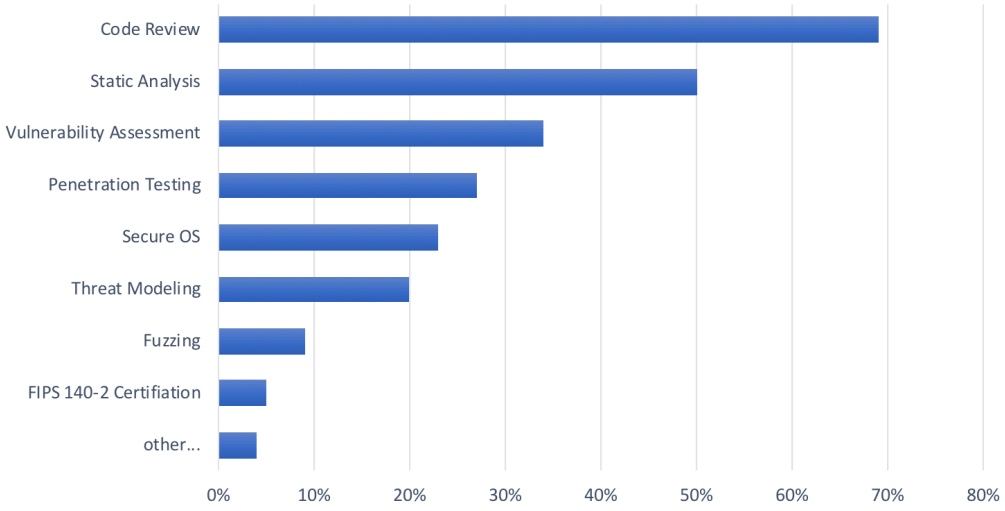


Figure 23. Percentage Use of Security-Related Processes

The Internet of Dangerous Things

Given that the majority of new embedded systems designs had connections to the Internet, it should not be surprising that a large number of safety-critical systems were going online too. Indeed, we identified a sizable subset (244) of respondents who were designing products that were both potentially injurious and on the Internet.[20] The percentages and numbers are broken down in Figure 24 and lead to a group we refer to henceforth as the Internet of Dangerous Things ("IoDT").

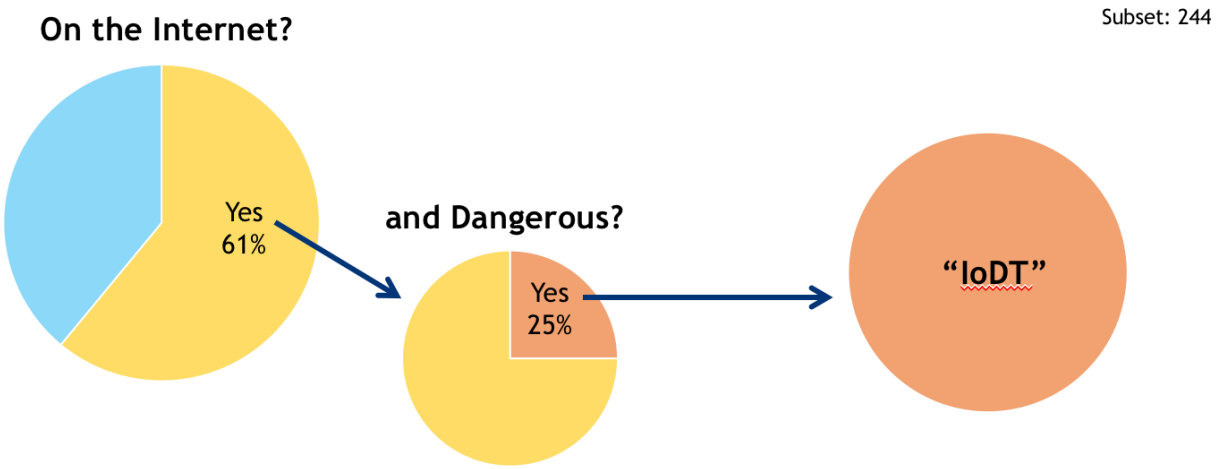


Figure 24. Percentage of Potentially Dangerous Systems with Internet Connections

Overall, about equal numbers could kill vs. merely cause injuries. A handful of industries were associated with more than two-thirds of the risk: Industrial Controls (22%), Medical Devices (19%), Automotive Systems (15%), Consumer Electronics (8%), and Farming/Construction (6%).

[20] Just 24% of these systems would be "always" on the Internet. Of course, systems that are on the Internet just some of the time can also be remotely hacked.

Findings

Broader use of software development best practices is also an opportunity to better secure the vast numbers of Internet-connected devices to come.

The security of a product depends in part on its reliability. For example, a medical device that can be made to malfunction by rapid pressing of keys could be attacked via that interface. Thus it is a security problem for the embedded systems industry as a whole that the best practice software development processes described above in the context of safety are not more widely utilized.

Figure 25 shows the rates of non-use of three best practices by the designers of potentially dangerous products that will be Internet-connected. Unbelievably, 38% of the designers of these systems either didn't have a written coding standard or didn't have any enforcement mechanism in place. With respect to peer code reviews, 26% never or rarely did them at all and 17% said they did code reviews only sporadically. More than a third (37%) didn't perform static analysis on their source code.

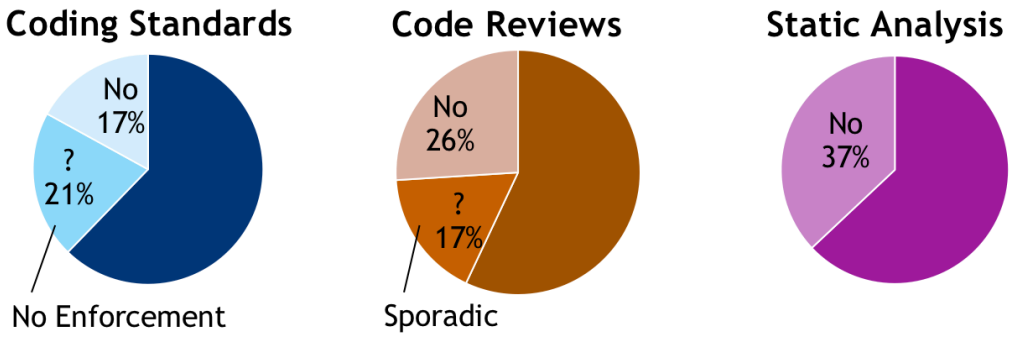


Figure 25. Percentage Non-Use of Best Practices on the Internet of Dangerous Things

Though there is obviously much more to designing a secure system than just following best practices for software development, these process steps represent some low-hanging fruit for the industry to potentially inexpensively raise IoT security.

About 1 in 6 designers of potentially injurious, Internet-connected embedded systems are completely ignoring security.

Disturbingly, as illustrated in Figure 26, about 1 in 6 of the designers of safety-critical systems that would be connected to the Internet said that security was not a "design requirement" at all on their project. This is clearly a serious issue. The Internet is obviously well-known to be a dangerous place for embedded systems—with examples including military-grade attacks (e.g., Stuxnet) to newsworthy wired and wireless botnet worms (e.g., Mirai and BlueBorne) and others.

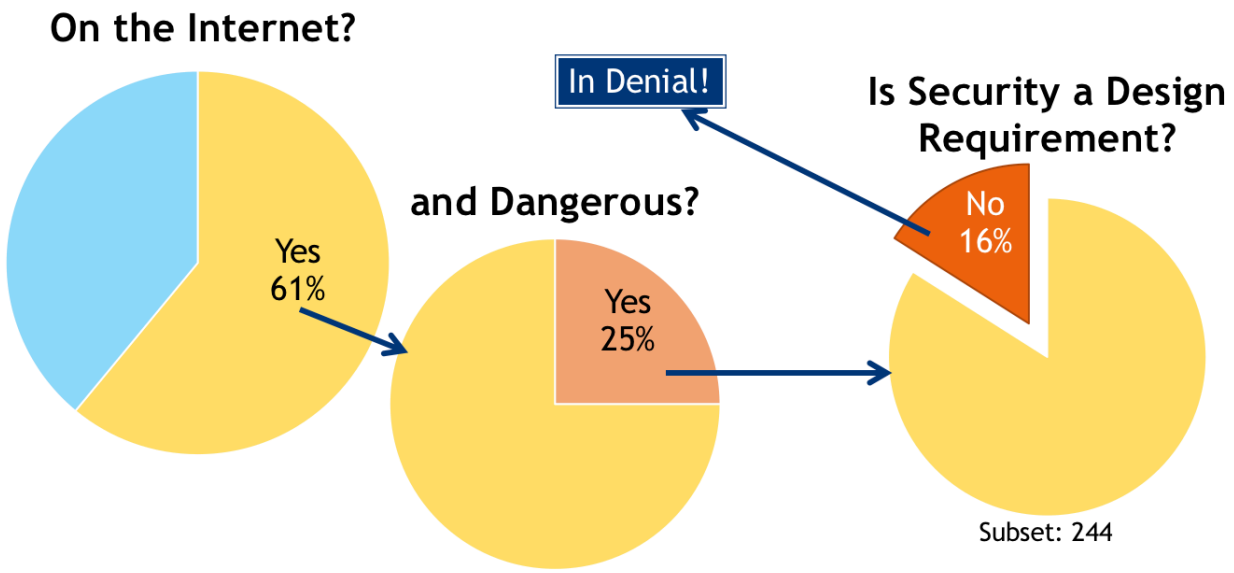


Figure 26. Percentage of Internet of Dangerous Things Designers Ignoring Security

One positive trend in this year's data is that fewer designers of Internet of Dangerous Things products were ignoring security compared with last year's 22%. However, the continued ignorance and/or denial is alarming. What horrifying deadly disaster need occur before designers of Internet-connected products will begin to take security seriously?

Because the range of architectures and applications is large, there will never be a one-size-fits-all solution to the problem of securing embedded systems.

Unlike software designed for general-purpose computers, embedded software cannot usually be run on other embedded systems without significant modification. This is primarily because of the incredible variety in the underlying hardware. The hardware in each embedded system is tailored specifically to the application, in order to keep system costs low. As a result, unnecessary circuitry is eliminated and hardware resources are shared wherever possible.

By definition all embedded systems contain at least one processor and software, but increasingly the number of microcontrollers and/or processor cores is itself a point of architectural differentiation. Only about a third of new product designs have just one processor while over a quarter have 4 or more. And each of these processors can be chosen from across dozens of popular semiconductor makers and instruction set families.[21]

The rest of the embedded hardware is equally unique. The inputs to an embedded system usually take the form of sensors and probes, communication signals, or control knobs and buttons. The outputs are typically displays, communications signals, or changes to the physical world. But these inputs and outputs vary incredibly widely across product types and target industries.

[21] That said, according to a recent report from VDC Research, the combined ARM Cortex-A/-R/-M processor families are the architecture of daily interaction for about 57% of embedded systems designers. Intel's x86 and Microchip's PIC appear to be the only other major architectures left standing at this point.

Architectural variation of the hardware and software is the result of many competing design criteria. Each embedded system is a product that must meet a completely different set of requirements, any or all of which may affect the compromises and tradeoffs made during the development of the product. For example, if the system must have a production cost below $10, then other things—like processing power, memory, and system reliability—may need to be sacrificed.

As illustrated by the data summarized in Figure 27, the hypothetical designer of a "one-size-fits" all security solution for embedded systems would be faced with a daunting challenge: the potential attack surfaces, number of processors to defend, and operating system platforms are among many factors that make such an easy solution impossible.

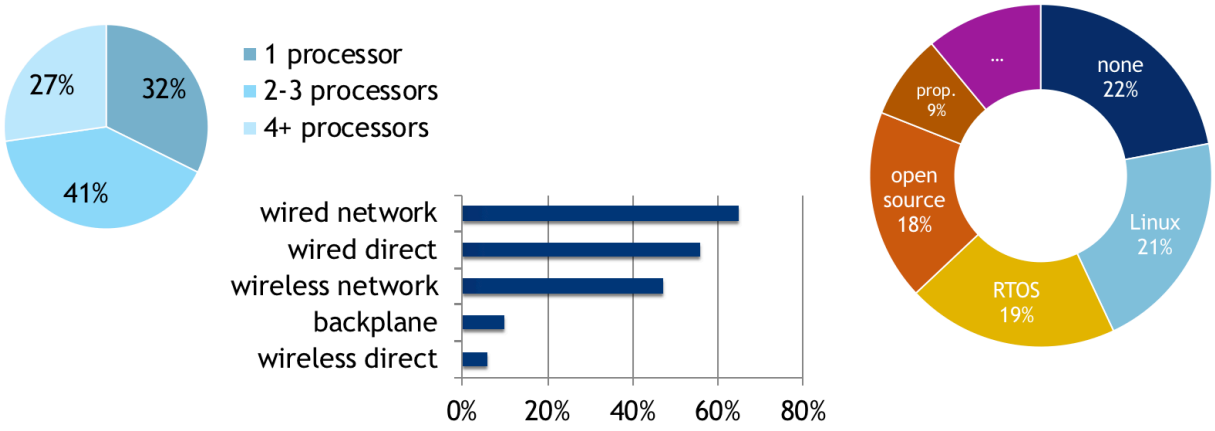


Figure 27. Diversity of Embedded Systems Hardware and Software Architectures

The solution space for embedded security is thus vast and unlikely to ever constitute an efficient market.

Barr Group

2018

Embedded Systems Safety & Security Survey

Appendix A: Survey Questions as Asked

2018 Embedded Systems Survey

Welcome to Barr Group's annual survey of embedded systems designers.

For the good of our industry and to protect the integrity of the data, please do not take this survey more than once.

* 1. Which of the following statements best describes you?

- ◯ I would like to participate in the 2018 survey and have not already taken it this year.
- ◯ I have already participated in the 2018 survey.
- ◯ I just want to enter the drawing for thank-you prizes.
- ◯ I don't belong here at all.

2018 Embedded Systems Survey

Thank you for taking a few minutes to help with this important annual survey of worldwide industry trends.

* 2. How much professional experience (paid work, not counting academic work) do you have in the field of embedded systems design?

- ◯ I have no professional experience in embedded systems design.
- ◯ 1-9 years
- ◯ 10-19 years
- ◯ 20-29 years
- ◯ 30+ years

2018 Embedded Systems Survey

* 3. What is your primary professional role in the design of embedded systems?

- ◯ Engineer or consultant with primarily a software/firmware design focus
- ◯ Engineer or consultant with primarily a hardware/electronics design focus
- ◯ Engineer or consultant who regularly does both software design and hardware design
- ◯ Engineer or consultant with primarily a system-level or architecture-level focus
- ◯ Manager with direct oversight of one or more design projects
- ◯ Executive or manager with no direct oversight of design projects
- ◯ I am primarily involved in ensuring product quality (e.g., testing and validation)
- ◯ I primarily teach/train others and/or work in an academic environment
- ◯ Other (please specify)

* 4. What is your current employment status?

- ◯ Full-time employee
- ◯ Part-time employee
- ◯ Consultant
- ◯ Unemployed
- ◯ Student
- ◯ Other (please specify)

2018 Embedded Systems Survey

Please answer all remaining questions about a single embedded systems design project you are currently involved with.

* 5. Which one of the following product categories best applies to your current project?

- Automation or Industrial Controls
- Consumer Electronics
- Gaming Devices or Systems
- Communications and Networking
- Scientific Instruments (e.g., oscilloscopes, colorimeters)
- Automotive Systems
- Transit/Transportation (e.g., rail, bus, boat)
- Farming or Construction Equipment
- Medical Devices or Instruments
- Aerospace or Defense
- Computers and Related Peripherals
- Oil or Gas Extraction or Refinement
- Electricity Generation or Distribution
- Public Utilities or Municipal Government
- Home or Business Security Systems
- Audio/Video/Image Capture/Processing/Playback
- Banking or Finance
- Semiconductors
- I don't know.
- Other (please specify)

* 6. What is the nature of your current project?

- ◯ Software-only upgrade/refinement for existing product
- ◯ Upgrade/refinement of hardware and software for existing product
- ◯ Complete redesign of existing product
- ◯ Cost reduction of hardware for existing product
- ◯ A brand new type of product, mostly from scratch
- ◯ A brand new type of product, mostly based on an earlier product
- ◯ I don't know.

* 7. How many total processors (including microcontrollers and cores) do you expect to be included?

- ◯ There are no processors.
- ◯ 1 processor
- ◯ 2 processors
- ◯ 3 processors
- ◯ 4 or more processors
- ◯ I don't know.

* 8. At peak effort, how many people will be involved in writing embedded software for your current project?

- ◯ None, because there's no embedded software on this project.
- ◯ 1 programmer
- ◯ 2-4 programmers
- ◯ 5-9 programmers
- ◯ 10-19 programmers
- ◯ 20+ programmers
- ◯ I don't know.

* 9. What type of primary operating system do you expect to run on the primary processor?

- ◯ A commercial (i.e., one you pay for) RTOS (e.g., MicroC/OS, VxWorks)
- ◯ A chip-vendor RTOS (e.g., TI/RTOS, MQX)
- ◯ A free RTOS (e.g., eCOS, FreeRTOS)
- ◯ Android
- ◯ Another flavor of Linux (whether commercial or free)
- ◯ A flavor of Microsoft Windows (desktop or embedded)
- ◯ A state machine framework (e.g., Quantum Platform)
- ◯ An industry-standard API (e.g., AUTOSAR/OSEK)
- ◯ A proprietary operating system (i.e., an in-house design)
- ◯ No operating system
- ◯ I don't know.
- ◯ Other (please specify)

* 10. What types of connections to other systems will your current project have? (select all that apply)

- ☐ One or more 1-to-many wired connections (e.g., Ethernet, CAN, or similar)
- ☐ One or more 1-to-1 wired connections (e.g., RS-232, or similar)
- ☐ One or more 1-to-many wireless connections (e.g., WiFi, Bluetooth, or similar)
- ☐ One or more 1-to-1 wireless connections (e.g., IrDA, or similar)
- ☐ One or more backplane connections (e.g., PCI, VME, or similar)
- ☐ No connections to other systems
- ☐ I don't know.

* 11. When, if at all, will your current project be connected (directly or indirectly) to the Internet?

- ◯ It will never be connected to the Internet
- ◯ It will sometimes be connected to the Internet
- ◯ It will always be connected to the Internet
- ◯ I don't know.

* 12. Do you consider your current project to be part of the "Internet of Things"?

- ◯ Yes
- ◯ No
- ◯ I don't know.

13. If you know, how will users interact with your current project? (select all that apply)

- ☐ Via a graphical user interface (a.k.a., GUI)
- ☐ Via physical controls (knobs/buttons/switches)
- ☐ Via an App (e.g., for iOS or Android) or PC-type application
- ☐ Via a web browser (i.e., there will be an embedded web server)
- ☐ Via a voice interface
- ☐ Via a command-line interface
- ☐ No user interaction
- ☐ Other (please specify)

* 14. Will the current project utilize machine learning (a.k.a., "AI") for any reason?

- ◯ No. Every behavior is pre-programmed by humans.
- ◯ Yes, there will be machine learning in the embedded system itself.
- ◯ Yes, but the machine learning will occur in the cloud.
- ◯ Yes, but the machine learning will only be used during the product development phase.
- ◯ I don't know.
- ◯ Other (please specify)

2018 Embedded Systems Survey

Still thinking about the same current embedded systems design project you are personally involved with...

* 15. What is the primary programming language for your current project?

- ◯ C
- ◯ C++
- ◯ Assembly
- ◯ Java
- ◯ C# / .NET
- ◯ Ada
- ◯ LabView
- ◯ I don't know.
- ◯ Other (please specify)

* 16. Does your team maintain its source code in a version control system?

- ◯ Yes
- ◯ No
- ◯ I don't know.

* 17. Are peer source code reviews a part of the software development process?

- ◯ We have a process in place that ensures regular code reviews for all code.
- ◯ We perform continuous peer review by pair programming.
- ◯ We conduct code reviews for some modules and/or when there is a problem.
- ◯ In theory we are supposed to hold code reviews, but we hardly or never actually do them.
- ◯ Code reviews are not part of our process and/or there is only one programmer.
- ◯ I don't know.

* 18. Is source code run through one or more static analysis tools (e.g., PC/Lint or Coverity)?

- ◯ Yes
- ◯ No
- ◯ I don't know.

19. If you know, what kinds of testing will be performed? (select all that apply; skip if none)

- ☐ Test-Driven Development (a.k.a., TDD)
- ☐ White Box Unit Testing (includes testing of all internal states of the unit)
- ☐ Black Box Unit Testing (ignores internal states, focusing only on outputs)
- ☐ Regression Testing (i.e., rerunning a suite of past tests on all new releases)
- ☐ System Testing (i.e., testing the software and hardware as a whole)
- ☐ Hardware-in-the-Loop Testing (i.e., testing software on hardware simulators)
- ☐ Other (please specify)

* 20. Are known defects formally tracked (e.g., in a bug database or issue tracking system)?

- ◯ Yes
- ◯ No
- ◯ I don't know.

* 21. Is there a written coding standard in place that applies to your current project?

- ◯ Yes
- ◯ No
- ◯ I don't know.

2018 Embedded Systems Survey

Still thinking about the same current embedded systems design project you are personally involved with...

* 22. What is the primary basis of the coding standard that applies to your current project?

- MISRA's Guidelines for Critical Systems for C or C++
- CERT's Secure Coding Standards for C, C++, or Java
- Lockheed's Joint Strike Fighter Standard for C++ (a.k.a, JSF++)
- High Integrity C++ Standard
- Barr Group's "Embedded C Coding Standard" Book
- Linux Kernel Coding Standard
- A proprietary coding standard (i.e., in-house developed)
- I don't know.
- Other (please specify)

* 23. How is the relevant coding standard enforced on your current project?

- Enforcement is automated and non-compliant code cannot be checked-in.
- Enforcement is partly automated with static analysis tool use.
- Enforcement is one of the issues checked during code reviews.
- There is no enforcement mechanism, though some programmers voluntarily comply.
- Our coding standard is a meaningless "write-once/read-never" document.
- I don't know.

2018 Embedded Systems Survey

Still thinking about <u>the same current embedded systems design project</u> you are personally involved with...

* 24. Is security one of the design considerations on your current project?

- ◯ Yes
- ◯ No
- ◯ I don't know.

2018 Embedded Systems Survey

Still thinking about <u>the same current embedded systems design project</u> you are personally involved with...

25. <u>If you know</u>, what are the primary security concerns with your current project? (select all that apply; skip if none)

- [ ] Product Cloning
- [ ] Theft of Intellectual Property
- [ ] Customer Privacy Violations
- [ ] Theft of Data
- [ ] Product Tampering
- [ ] Theft of Service
- [ ] Denial of Service
- [ ] Injury or Death
- [ ] Blackmail or Ransom
- [ ] Other (please specify)

26. If you know, which of the following security layers are used on your current project? (select all that apply; skip if none)

- [ ] Non-Volatile Memory Protections
- [ ] Mechanical Tamper Detection
- [ ] Network Intrusion Detection
- [ ] Access Control (e.g., user authentication)
- [ ] Encrypted and Authenticated External Communications (e.g., SSL/TLS)
- [ ] Encrypted Internal Communications
- [ ] Secure Boot Process
- [ ] Secure Firmware Updates
- [ ] Public Key Cryptography
- [ ] Obfuscation
- [ ] Other (please specify)

27. If you know, which of the following processes are usedto increase security on your current project? (select all that apply; skip if none)

- [ ] Threat Modeling
- [ ] Code Review
- [ ] Static Analysis
- [ ] FIPS 140-2 Certification
- [ ] Fuzzing
- [ ] Secure Operating System
- [ ] Vulnerability Assessment
- [ ] Penetration Testing
- [ ] Other (please specify)

28. Will your team hire any outside security experts to help increase the security of the final product?

- ( ) Yes
- ( ) No
- ( ) I don't know.

2018 Embedded Systems Survey

Still thinking about <u>the same current embedded systems design project</u> you are personally involved with...

* 29. If the product resulting from your current project malfunctioned, what is the worst possible outcome?

- ◯ Death of Multiple People
- ◯ Death of One Person
- ◯ Serious Injury of One or More People
- ◯ Minor Injury to One or More People
- ◯ Product Recall by Company
- ◯ Diminished Sales and/or Brand Reputation
- ◯ Customers Return Products
- ◯ Customers are Annoyed
- ◯ I don't know.

30. If you know, with which of the following safety standards is the product intended to comply? (select all that apply; skip if none)

- [ ] 26262
- [ ] 61508
- [ ] DO-178
- [ ] FDA 510(k)
- [ ] DO-254
- [ ] 60601
- [ ] MISRA
- [ ] 62304
- [ ] Other (please specify)

31. Will your team hire any outside experts to help increase the safety or reliability of the product?

- ( ) Yes
- ( ) No
- ( ) I don't know.

2018 Embedded Systems Survey

* 32. Approximately how many total people work at your company (across all locations)?

- 1-9 people
- 10-99 people
- 100-999 people
- 1,000-9,999 people
- 10,000+ people
- I don't know.

* 33. Approximately how many engineers (of any type) work at the company?

- 1-9 engineers
- 10-99 engineers
- 100-999 engineers
- 1,000+ engineers
- I don't know.

34. If you know, what methods of career skills development does your company pay for with respect to its engineers? (select all that apply; skip if none)

- [ ] Industry trade shows (e.g., Embedded Systems Conference)
- [ ] University courses or part-time degree programs
- [ ] Professional association memberships (e.g., IEEE or ACM)
- [ ] On-site training courses presented by outside instructors
- [ ] Off-site training courses at other companies or locations
- [ ] Web-based training videos or courses (that are not free)
- [ ] Books and/or other packaged training resources or kits
- [ ] Other (please specify)

2018 Embedded Systems Survey

35. In which country *or region* do you currently reside?

- ◯ United States
- ◯ Canada
- ◯ *Elsewhere in the Americas*
- ◯ United Kingdom
- ◯ Germany
- ◯ France
- ◯ Spain
- ◯ Italy
- ◯ *Scandanavia*
- ◯ *Eastern Europe or Russia*
- ◯ *Elsewhere in Europe*
- ◯ India
- ◯ China
- ◯ Japan
- ◯ *Elsewhere in Asia*
- ◯ *Oceania*
- ◯ *Middle East*
- ◯ *Africa*
- ◯ *Elsewhere in the World*

2018 Embedded Systems Survey

36. In which part of the United States do you currently reside?

- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- District of Columbia (DC)
- Florida
- Georgia
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine
- Maryland
- Massachusetts

- Michigan
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- Nevada
- New Hampshire
- New Jersey
- New Mexico
- New York
- North Carolina
- North Dakota
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- Puerto Rico
- Rhode Island
- South Carolina
- South Dakota
- Tennessee
- Texas
- Utah
- Vermont
- Virginia
- Washington
- West Virginia
- Wisconsin
- Wyoming
- Other (please specify)

Barr Group

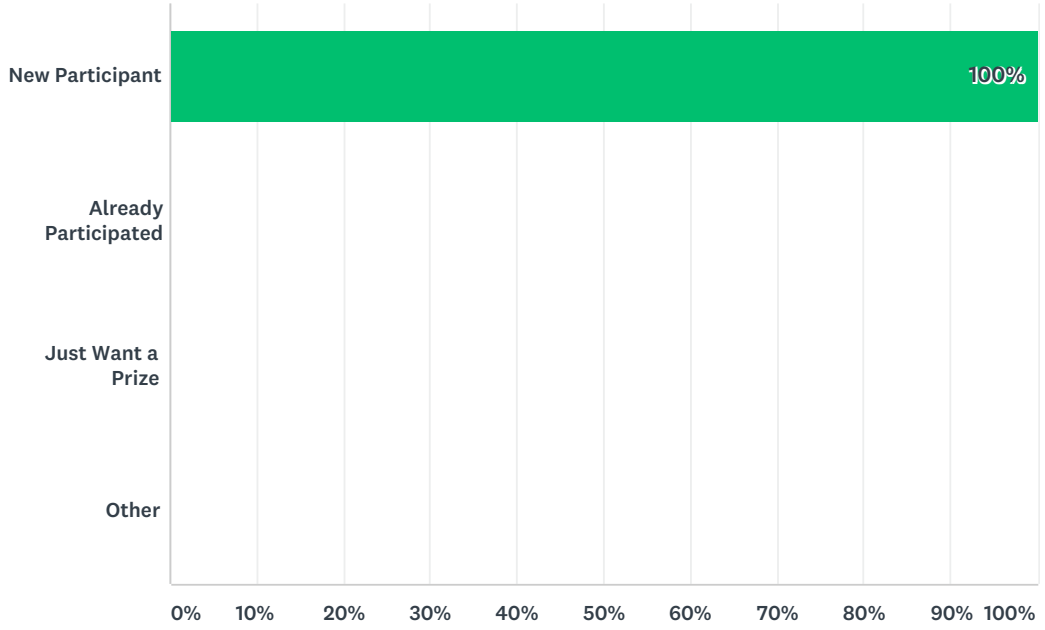
2018

Embedded Systems Safety & Security Survey

Appendix B: Qualified Responses as Received

Q1 Which of the following statements best describes you?

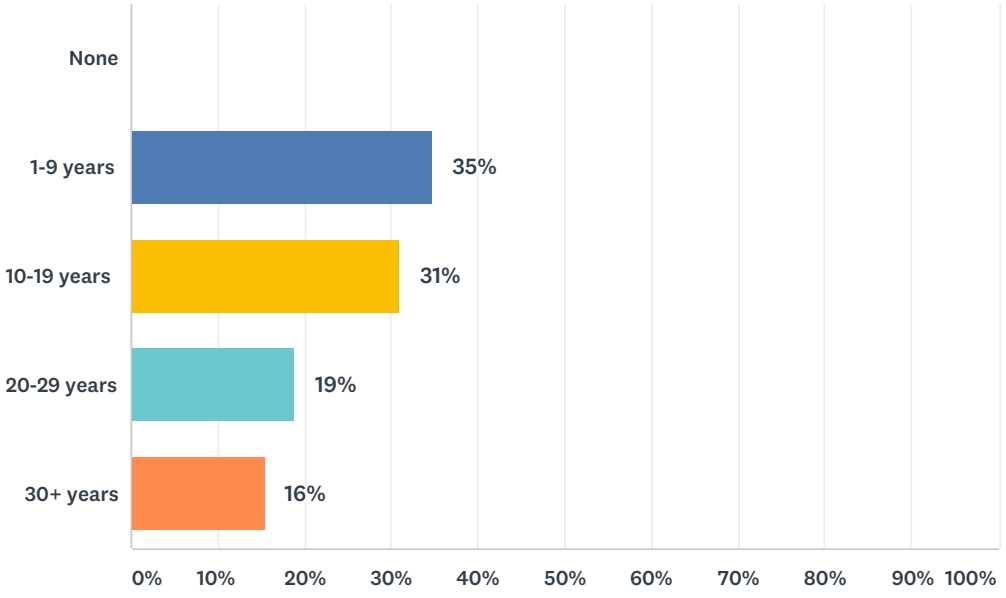
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
New Participant	100%	1,703
Already Participated	0%	0
Just Want a Prize	0%	0
Other	0%	0
TOTAL		1,703

Q2 How much professional experience (paid work, not counting academic work) do you have in the field of embedded systems design?

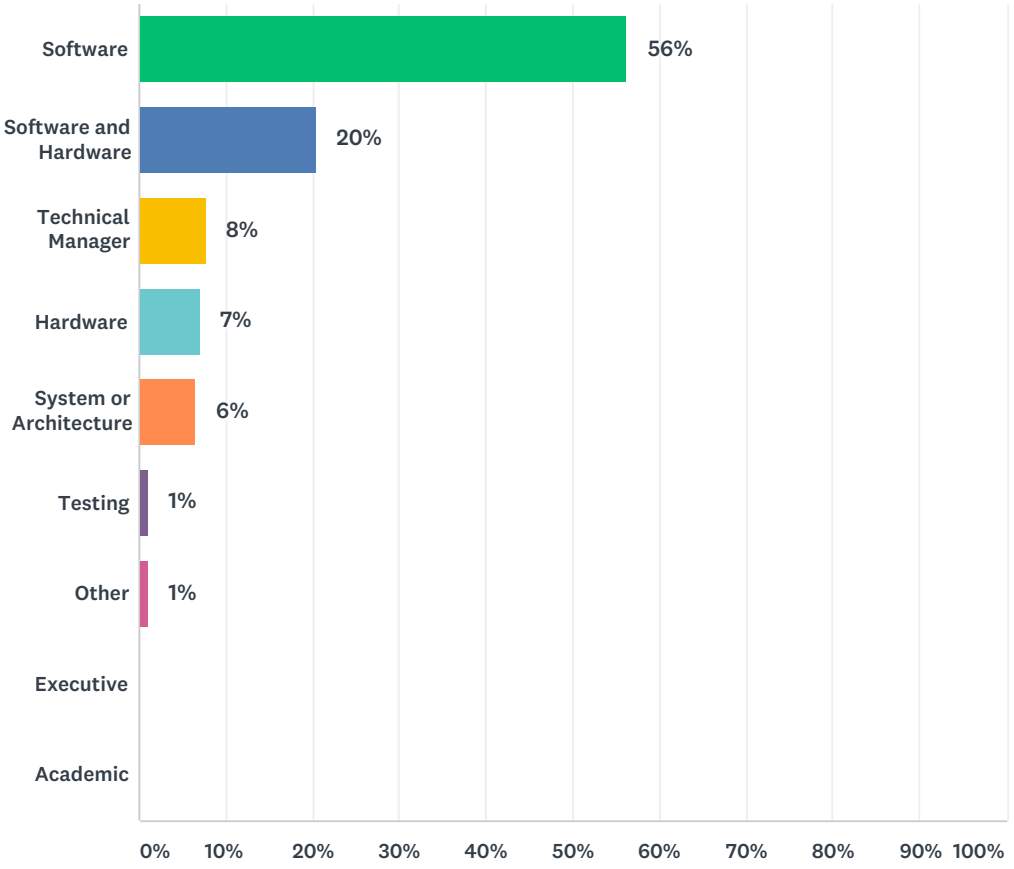
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
None	0%	0
1-9 years	35%	593
10-19 years	31%	526
20-29 years	19%	319
30+ years	16%	265
TOTAL		1,703

Q3 What is your primary professional role in the design of embedded systems?

Answered: 1,703 Skipped: 0



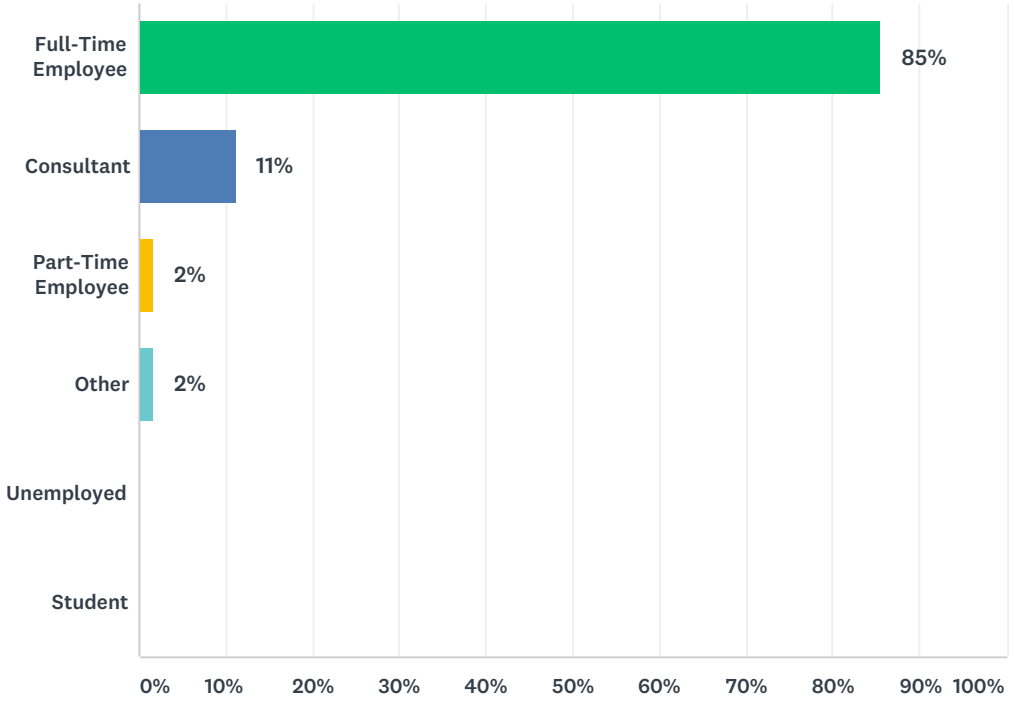
ANSWER CHOICES	RESPONSES	
Software	56%	959
Software and Hardware	20%	348
Technical Manager	8%	132
Hardware	7%	121
System or Architecture	6%	109
Testing	1%	17
Other	1%	17
Executive	0%	0
Academic	0%	0
TOTAL		1,703

#	OTHER (PLEASE SPECIFY)	DATE
1	Doing architectural management, hardware and firmware design	1/31/2018 5:14 AM

2	Requirement Engineer	1/30/2018 11:26 PM
3	I manage a team, but also have extensive hands on experience, and still get my hands dirty. Hardware, firmware, and system integration.	1/30/2018 9:46 PM
4	Bridge person between design and marketing	1/29/2018 8:59 AM
5	aid post silicon from linux kernel perspective, give h/w teams input on what kernel is doing, which blocks are being used etc.	1/25/2018 2:44 PM
6	I specialise in Software Safety	1/25/2018 9:46 AM
7	ISA design and development tool design	1/24/2018 9:41 PM
8	Embedded control system software and firmware	1/20/2018 1:56 PM
9	I train others in a non-academic environment	1/17/2018 11:55 AM
10	Heading the SBU	1/17/2018 3:18 AM
11	Sales	1/17/2018 2:13 AM
12	Founder/CEO with direct management off hardware & software design	1/17/2018 12:46 AM
13	Engineer or consultant who regularly does both software design and hardware design and system-level and architecture-level	1/15/2018 7:06 PM
14	manager who also does systems engineering and technical work... mostly SW focus. Occausional lecturer	1/10/2018 8:14 PM
15	Engineer with a software/firmware and system-level or architecture-level focus	1/9/2018 4:19 PM
16	Technical customer support engineer	1/9/2018 2:21 PM
17	provider of a security platform for embedded software	1/9/2018 2:15 PM

Q4 What is your current employment status?

Answered: 1,703 Skipped: 0



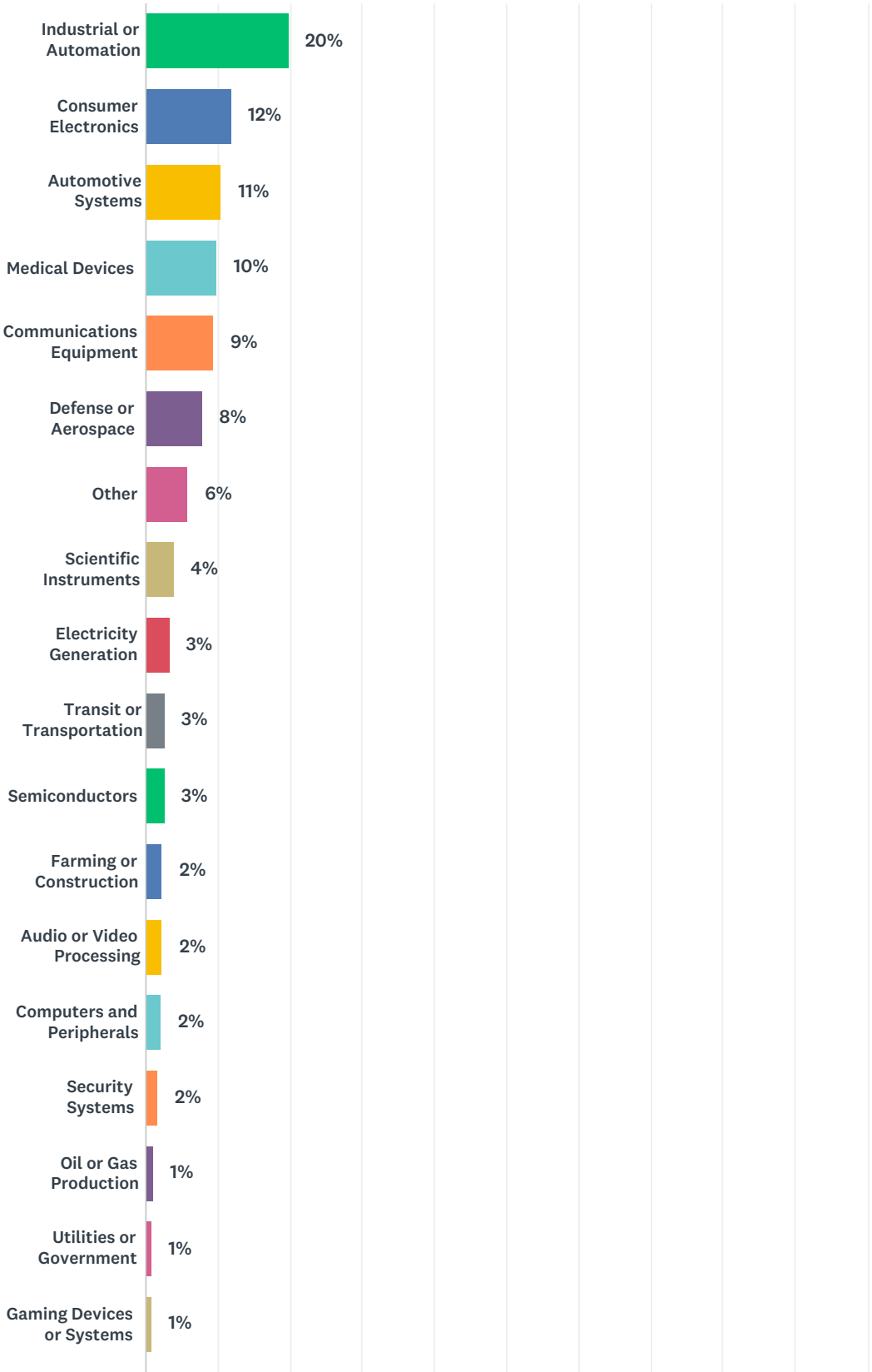
ANSWER CHOICES	RESPONSES	
Full-Time Employee	85%	1,456
Consultant	11%	192
Part-Time Employee	2%	28
Other	2%	27
Unemployed	0%	0
Student	0%	0
TOTAL		1,703

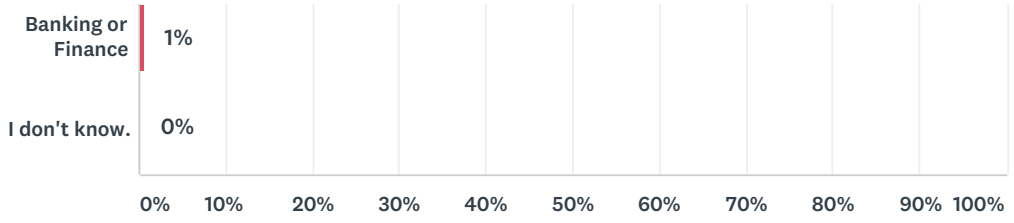
#	OTHER (PLEASE SPECIFY)	DATE
1	Business owner plus contract developer	1/29/2018 11:06 PM
2	self employed	1/26/2018 9:18 AM
3	Entrepreneur	1/25/2018 4:37 PM
4	Part time employee at moment, but I usually work as a consultant.	1/24/2018 9:18 PM
5	Former embedded engineer (19 years); current patent attorney (past 12 years) with primary focus in electronics/firmware/embedded systems	1/24/2018 2:57 AM
6	Retired	1/24/2018 2:31 AM
7	Full-time employed and owner operator of electronics startup.	1/23/2018 9:16 PM
8	Freelance Programmer and Trainer	1/23/2018 2:29 AM
9	Full-time Owner	1/22/2018 7:01 PM

10	Business owner	1/22/2018 4:36 PM
11	Retired	1/22/2018 2:39 PM
12	Partner	1/22/2018 12:39 PM
13	self employed	1/22/2018 10:31 AM
14	Self employed	1/22/2018 10:25 AM
15	Full-time employee (day job) AND consultant (side work)	1/21/2018 11:56 PM
16	Both part time employee and consultant	1/21/2018 11:33 PM
17	Self Employed (Full Time)	1/19/2018 1:20 PM
18	independant, self-employed	1/17/2018 9:30 AM
19	Full time CEO/Founder	1/17/2018 12:46 AM
20	retired sandia national laboratories	1/17/2018 12:38 AM
21	retired	1/16/2018 10:58 PM
22	Between projects	1/16/2018 10:42 PM
23	Firm owner	1/16/2018 9:09 PM
24	Own my own dev/design business	1/16/2018 8:42 PM
25	both FTE and consultant	1/10/2018 8:14 PM
26	Full-time employee and student	1/10/2018 4:26 PM
27	Full time and consultant	1/9/2018 2:27 PM

Q5 Which one of the following product categories best applies to your current project?

Answered: 1,703 Skipped: 0





ANSWER CHOICES	RESPONSES	
Industrial or Automation	20%	339
Consumer Electronics	12%	203
Automotive Systems	11%	179
Medical Devices	10%	168
Communications Equipment	9%	161
Defense or Aerospace	8%	134
Other	6%	100
Scientific Instruments	4%	67
Electricity Generation	3%	56
Transit or Transportation	3%	48
Semiconductors	3%	47
Farming or Construction	2%	38
Audio or Video Processing	2%	38
Computers and Peripherals	2%	37
Security Systems	2%	27
Oil or Gas Production	1%	18
Utilities or Government	1%	16
Gaming Devices or Systems	1%	14
Banking or Finance	1%	9
I don't know.	0%	4
TOTAL		1,703

#	OTHER (PLEASE SPECIFY)	DATE
1	Lighting controls	1/31/2018 10:18 AM
2	structural health monitoring	1/31/2018 8:15 AM
3	Fire Services	1/31/2018 2:25 AM
4	Security	1/30/2018 11:13 PM
5	refrigerant recovery	1/30/2018 10:43 PM
6	AV networking	1/30/2018 10:39 PM
7	Solar powered lighting and marking	1/30/2018 10:13 PM
8	Prototypes & showcases across various domains: consumer, automotive, automation.	1/30/2018 9:56 PM

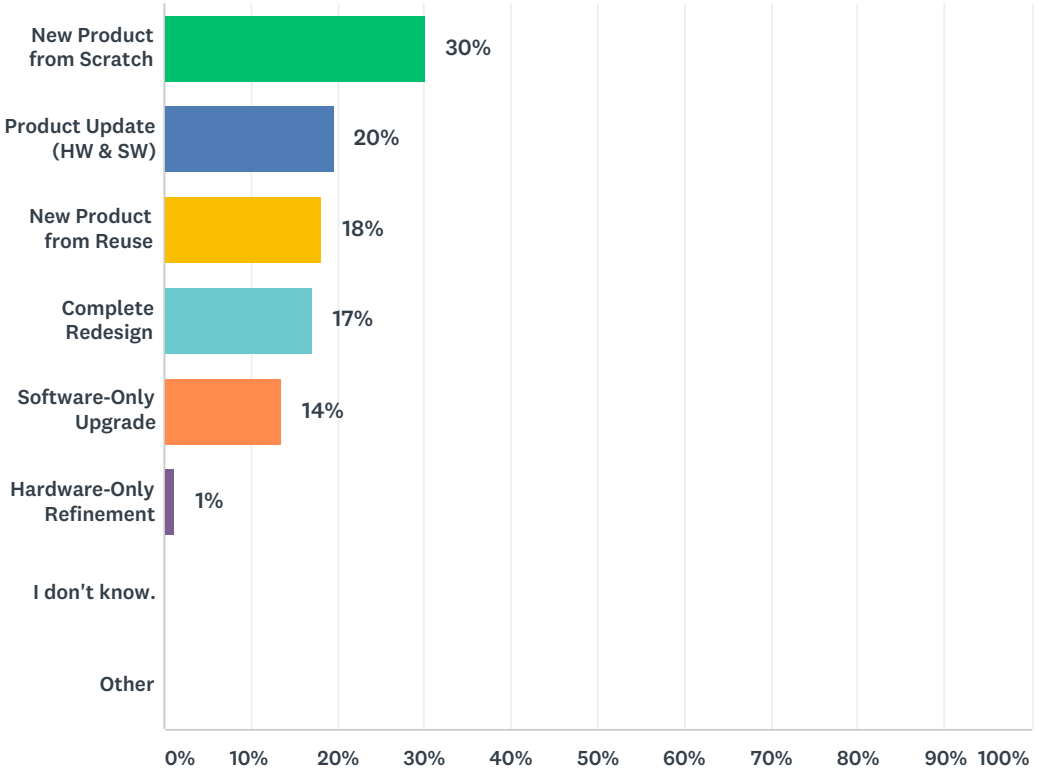
9	Fleet and asset management	1/30/2018 9:49 PM
10	Internet of Things	1/30/2018 12:57 PM
11	industrial battery chargers and AC-DC gear	1/30/2018 6:45 AM
12	Sports medicine device	1/29/2018 11:09 PM
13	Industrial testing equipment	1/29/2018 7:44 PM
14	Telecomm Power Systems	1/29/2018 4:26 PM
15	Measuring instrument	1/26/2018 11:23 AM
16	art-installation	1/26/2018 9:22 AM
17	Software tools for embedded sw dev	1/25/2018 8:30 PM
18	Energy Metering	1/25/2018 8:20 PM
19	Commercial/Industrial Equipment	1/25/2018 1:25 PM
20	Test equipment	1/25/2018 11:39 AM
21	IoT meteorological monitoring	1/25/2018 9:45 AM
22	SDR	1/25/2018 8:50 AM
23	Defense	1/25/2018 4:08 AM
24	biometrics	1/25/2018 1:16 AM
25	IOT - a 'smart' solar inverter	1/25/2018 12:33 AM
26	HVAC	1/24/2018 11:59 PM
27	Massive parallel processor ISA for applications using 100's processors	1/24/2018 9:47 PM
28	Our customers are represented in all of these groups	1/24/2018 9:37 PM
29	OEM application	1/24/2018 9:05 PM
30	Machine control	1/24/2018 9:01 PM
31	payment system	1/24/2018 8:32 AM
32	Inspection equipment	1/24/2018 7:37 AM
33	maker products	1/24/2018 7:04 AM
34	Academic related development boards	1/24/2018 5:33 AM
35	Regular work in automation, industrial & consumer electronics, comms, medical devices, computing devices, semiconductors & SoC at silicon level	1/24/2018 3:02 AM
36	Solar	1/23/2018 8:42 PM
37	Security	1/23/2018 8:39 PM
38	Smart Energy Metering System	1/23/2018 7:45 AM
39	Point of Sale Equipment	1/23/2018 6:08 AM
40	iot sensors	1/23/2018 3:11 AM
41	General purpose (can be used for any of the above)	1/22/2018 8:09 PM
42	Power/Electricity monitoring	1/22/2018 7:08 PM
43	Consumer and Scientific And Aerospace/Defense (See previous question, Consultant)	1/22/2018 6:57 PM
44	measurements system	1/22/2018 6:00 PM
45	Vertical Transportation (e.g. elevators)	1/22/2018 4:22 PM
46	Industrial Equipment Monitoring	1/22/2018 4:00 PM
47	Industrial Electronics	1/22/2018 3:50 PM
48	Design services firm; Highly varied	1/22/2018 3:08 PM

49	Industrial Control/Monitoring	1/22/2018 2:14 PM
50	Watter Heating	1/22/2018 2:06 PM
51	Forklifts	1/22/2018 12:07 PM
52	Safety	1/22/2018 12:06 PM
53	Telematics	1/22/2018 10:32 AM
54	Industry: Mines, Bridge, ...	1/22/2018 10:31 AM
55	Drones	1/21/2018 1:40 PM
56	Art Entertainment	1/21/2018 3:59 AM
57	3D Printers	1/19/2018 11:09 PM
58	Nuclear Fusion real-time control and diagnostics	1/19/2018 11:03 AM
59	Product Evaluation, primarily of embedded development kits	1/17/2018 9:39 PM
60	Energy storage	1/17/2018 2:53 PM
61	Athletic performance improvement	1/17/2018 12:23 PM
62	Smartcities	1/17/2018 4:59 AM
63	Physical device	1/17/2018 12:40 AM
64	Industrial Solar Lighting	1/17/2018 12:11 AM
65	Supply chain	1/16/2018 10:19 PM
66	instructional devices	1/16/2018 10:07 PM
67	aircraft galley equipment	1/16/2018 9:23 PM
68	Many of above	1/16/2018 9:10 PM
69	Home Automation	1/16/2018 9:05 PM
70	Hospitality HVAC	1/16/2018 8:35 PM
71	Lighting Control and general energy saving / energy management	1/16/2018 10:50 AM
72	Design services (multiple industries, but lots of IoT lately)	1/16/2018 12:40 AM
73	White goods ?	1/15/2018 7:08 PM
74	metering devices	1/14/2018 10:51 PM
75	Videosurveillance	1/14/2018 12:56 AM
76	oceanographic instrumentation	1/11/2018 5:59 PM
77	Fire fighting equipment	1/11/2018 3:48 PM
78	Gas Detection Equipment	1/11/2018 1:24 PM
79	Dataloggers for water/electricity applications and lighting controls	1/11/2018 3:30 AM
80	Health monitoring	1/10/2018 8:37 PM
81	Commercial Kitchen Equipment	1/10/2018 8:12 PM
82	Smart sensors	1/10/2018 5:53 PM
83	Sensors and Data Logging	1/10/2018 4:43 PM
84	Gas, water, electric metering networks	1/10/2018 4:25 PM
85	Telemetry	1/10/2018 4:22 PM
86	Lightning	1/10/2018 4:12 PM
87	Horizontal IIoT technology	1/10/2018 3:42 PM
88	Surveyors/construction	1/10/2018 3:33 PM
89	IOT	1/10/2018 1:07 PM

90	I serve cliets/projects in multiple industries at the same time.	1/9/2018 11:13 PM
91	Oil and gas survey equipment design	1/9/2018 7:52 PM
92	Internet connected Desks and Chairs	1/9/2018 6:43 PM
93	Cyber Security	1/9/2018 5:32 PM
94	Industrial Tool Manufacturing (Lasers)	1/9/2018 5:01 PM
95	Building Automation and intelligent systems	1/9/2018 4:36 PM
96	Avionics	1/9/2018 2:43 PM
97	Food Service	1/9/2018 2:35 PM
98	Almost any product categories.	1/9/2018 2:25 PM
99	Internet of Things in crops' post-harvesting processes	1/9/2018 2:02 PM
100	Wearable	1/9/2018 1:53 PM

Q6 What is the nature of your current project?

Answered: 1,703 Skipped: 0

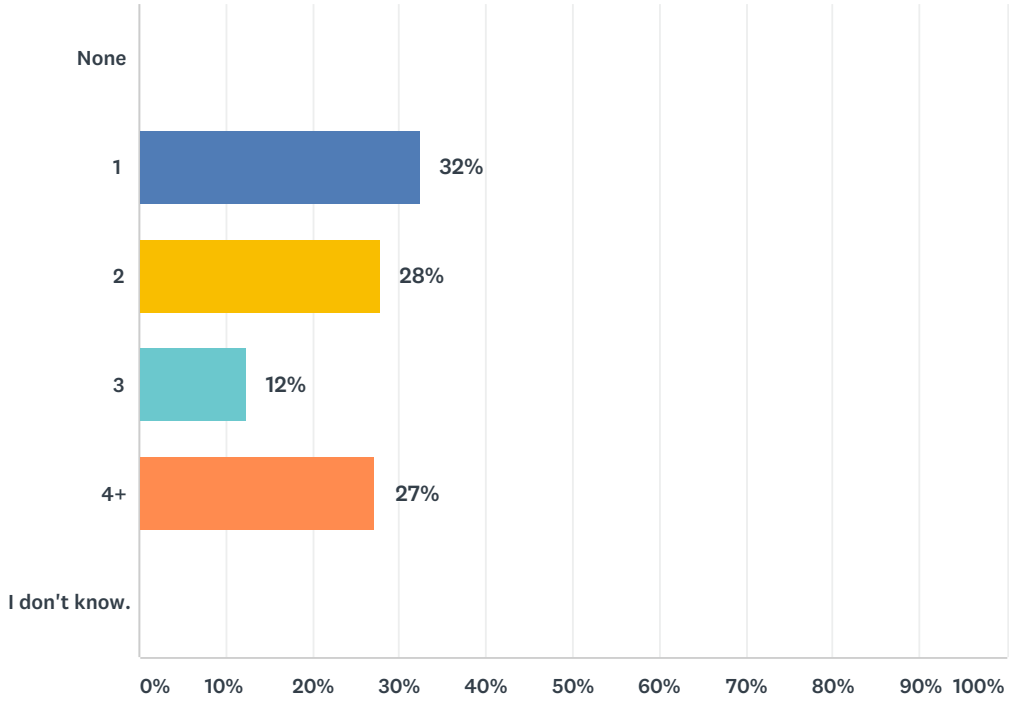


ANSWER CHOICES	RESPONSES	
New Product from Scratch	30%	512
Product Update (HW & SW)	20%	336
New Product from Reuse	18%	311
Complete Redesign	17%	291
Software-Only Upgrade	14%	232
Hardware-Only Refinement	1%	21
I don't know.	0%	0
Other	0%	0
TOTAL		1,703

#	OTHER (PLEASE SPECIFY)	DATE
	There are no responses.	

Q7 How many total processors (including microcontrollers and cores) do you expect to be included?

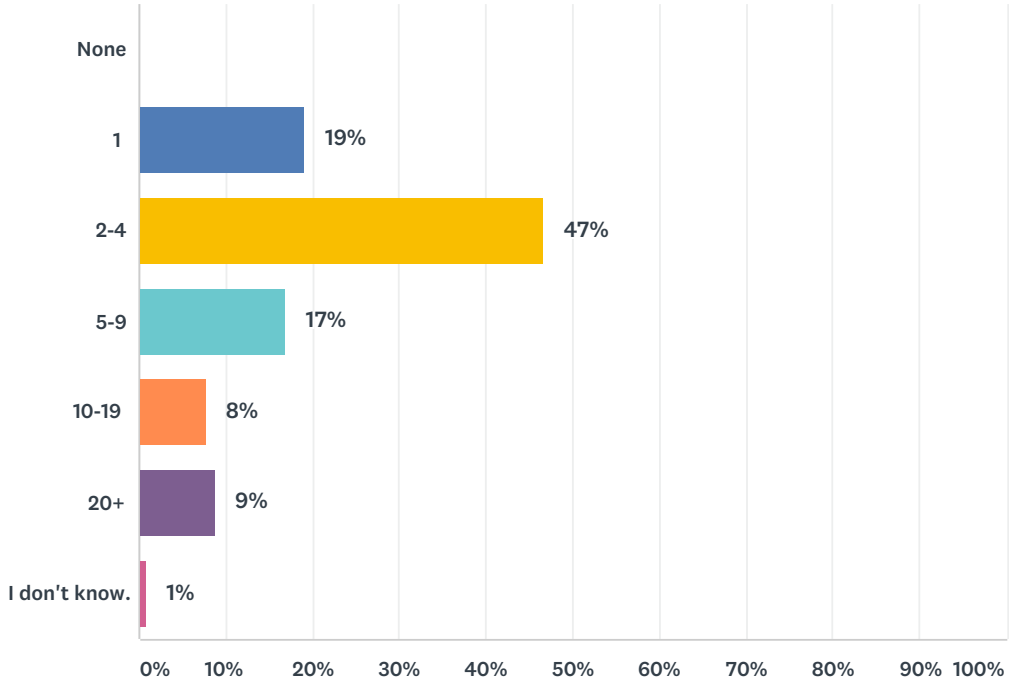
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
None	0%	0
1	32%	553
2	28%	475
3	12%	211
4+	27%	464
I don't know.	0%	0
TOTAL		1,703

Q8 At peak effort, how many people will be involved in writing embedded software for your current project?

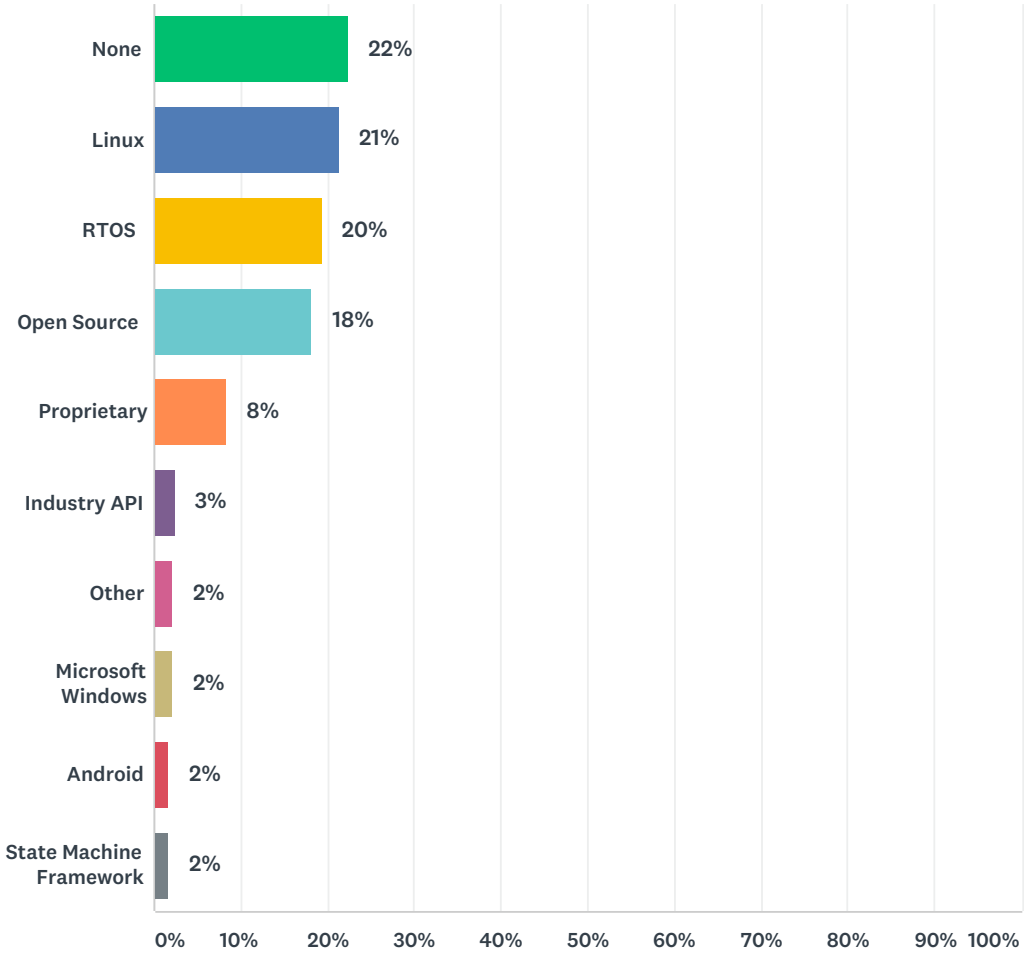
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
None	0%	0
1	19%	325
2-4	47%	794
5-9	17%	289
10-19	8%	133
20+	9%	148
I don't know.	1%	14
TOTAL		1,703

Q9 What type of primary operating system do you expect to run on the primary processor?

Answered: 1,703 Skipped: 0



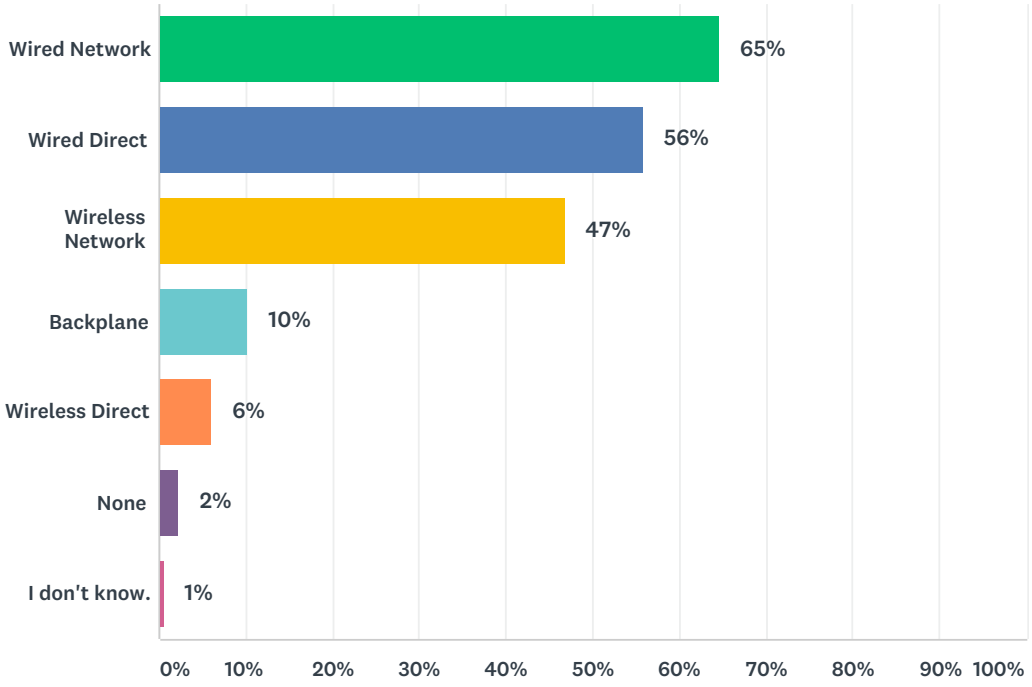
ANSWER CHOICES	RESPONSES	
None	22%	378
Linux	21%	359
RTOS	20%	329
Open Source	18%	305
Proprietary	8%	142
Industry API	3%	43
Other	2%	36
Microsoft Windows	2%	35
Android	2%	28
State Machine Framework	2%	27

TOTAL	1,682

#	OTHER (PLEASE SPECIFY)	DATE
1	Protothreads	1/31/2018 10:45 AM
2	No OS and Linux	1/31/2018 7:58 AM
3	mynewt	1/30/2018 11:38 PM
4	It's developed entirely develop by my team.	1/30/2018 11:29 PM
5	No operating system, or proprietary in which i know all the timings	1/30/2018 12:54 PM
6	Customer dependent: QNX, iOS, Android, Linux, other	1/29/2018 11:33 PM
7	MS-DOS	1/29/2018 7:44 PM
8	What is Primary, this system has it all...	1/24/2018 10:22 PM
9	In-house RTOS and Linux (Both will be working Simultaneously)	1/24/2018 8:30 AM
10	O/S agnostic	1/24/2018 3:02 AM
11	Multiple os and platforms	1/23/2018 10:37 PM
12	ThreadX	1/23/2018 10:06 PM
13	Can not say	1/23/2018 9:23 PM
14	Green Hills INTEGRITY-178	1/23/2018 9:04 PM
15	Green Hills INTEGRITY	1/22/2018 9:55 PM
16	a free RTOS which supports industry standard APIs (RTEMS)	1/22/2018 3:59 PM
17	Inhouse state machine	1/22/2018 3:40 PM
18	osek	1/22/2018 10:31 AM
19	Embedded rtos based on AUTOSAR and also Linux variant	1/17/2018 6:40 AM
20	Vxworks	1/17/2018 2:18 AM
21	forth 8051 or 8086 + windows 10/1709	1/17/2018 12:52 AM
22	Windriver	1/16/2018 10:03 PM
23	It's a TI MultiCore DSP, so DSP/BIOS	1/16/2018 9:10 PM
24	I have multiple projects. Some linux some mbed OS or freertos	1/16/2018 12:40 AM
25	GHS Integrity	1/15/2018 10:02 PM
26	The current project runs on a hyper-visor. Integrity OS and Linux	1/11/2018 7:16 AM
27	Android on BBB, and simple task handler for the 3 micros	1/11/2018 2:38 AM
28	VxWorks 6.9 and 7.X	1/10/2018 8:02 PM
29	OOP, with couple design pattern	1/10/2018 7:20 PM
30	myNewt	1/10/2018 6:36 PM
31	Variour types with rtos, or simple scheduler based system	1/10/2018 5:10 PM
32	SiLabs ZigBee stack	1/10/2018 4:18 PM
33	Multiple: Win, Linux, Android, bare metal loop	1/9/2018 11:13 PM
34	TI OSAL default implementation (cooperative priority scheduler)	1/9/2018 5:31 PM
35	ChibiOS	1/9/2018 3:06 PM
36	Own Linux based source distribution based on build system.	1/9/2018 1:59 PM

Q10 What types of connections to other systems will your current project have? (select all that apply)

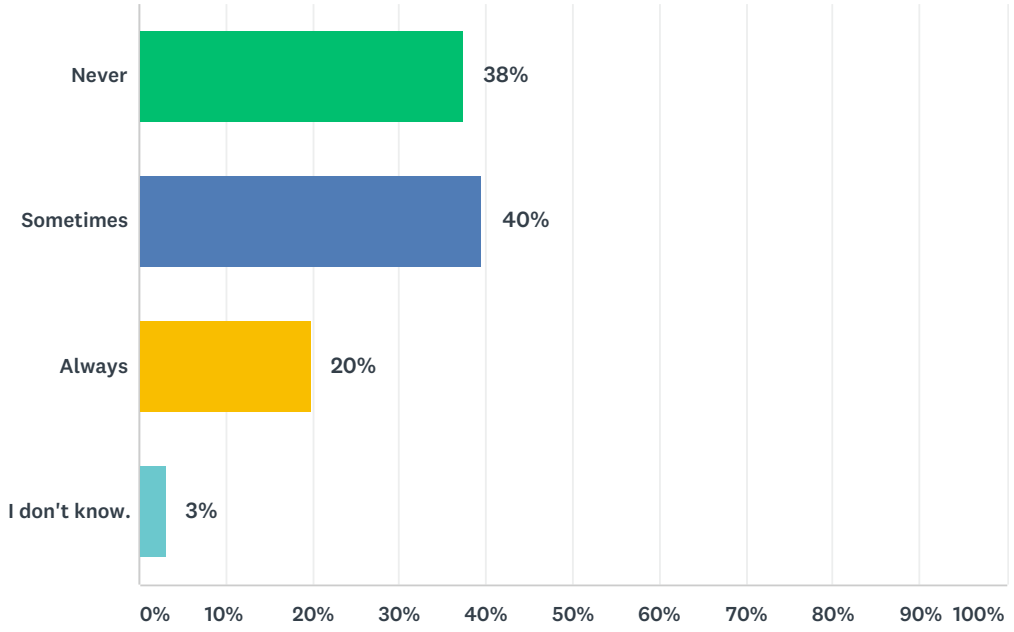
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Wired Network	65%	1,102
Wired Direct	56%	952
Wireless Network	47%	798
Backplane	10%	175
Wireless Direct	6%	104
None	2%	38
I don't know.	1%	9
Total Respondents: 1,703		

Q11 When, if at all, will your current project be connected (directly or indirectly) to the Internet?

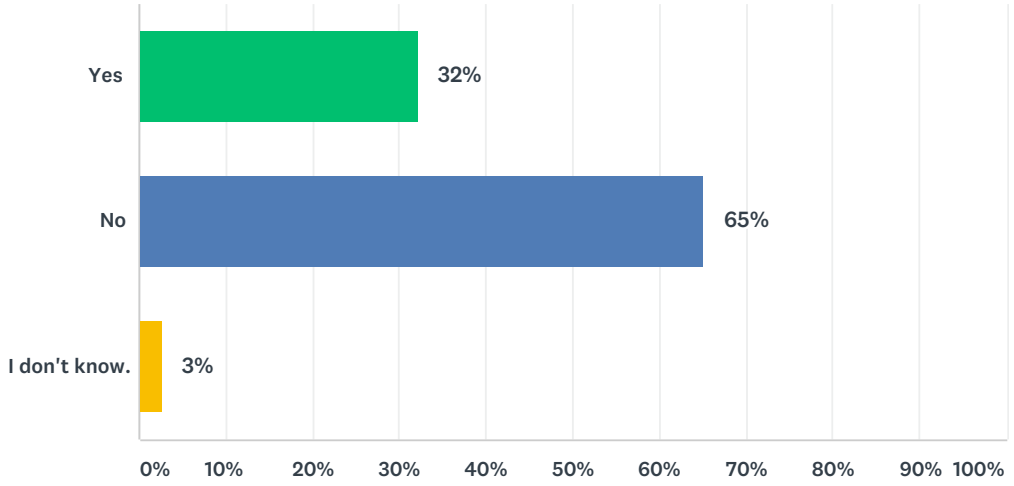
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Never	38%	639
Sometimes	40%	675
Always	20%	337
I don't know.	3%	52
TOTAL		1,703

Q12 Do you consider your current project to be part of the "Internet of Things"?

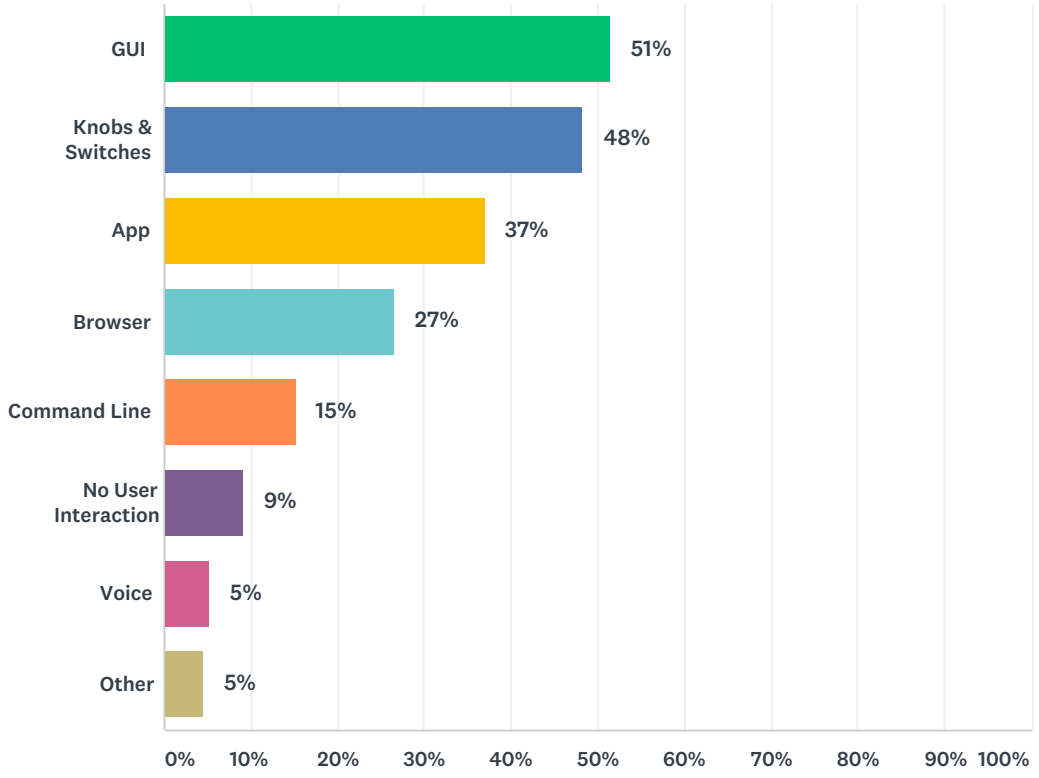
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	32%	547
No	65%	1,108
I don't know.	3%	48
TOTAL		1,703

Q13 If you know, how will users interact with your current project? (select all that apply)

Answered: 1,679 Skipped: 24



ANSWER CHOICES	RESPONSES	
GUI	51%	864
Knobs & Switches	48%	813
App	37%	623
Browser	27%	445
Command Line	15%	258
No User Interaction	9%	156
Voice	5%	89
Other	5%	77
Total Respondents: 1,679		

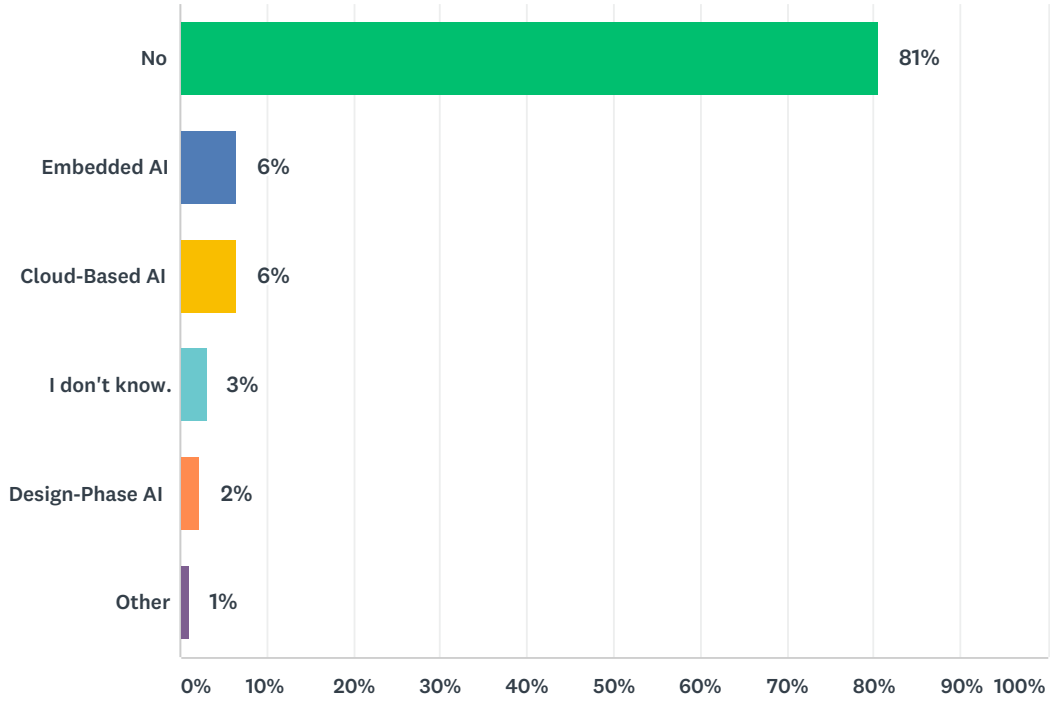
#	OTHER (PLEASE SPECIFY)	DATE
1	Analog and discrete digital signal interface.	2/1/2018 4:33 AM
2	USB host msd	1/31/2018 12:19 PM
3	CAN signalling	1/31/2018 10:13 AM
4	RF proprietary	1/31/2018 8:47 AM

5	Telephone	1/31/2018 1:44 AM
6	messaging	1/30/2018 11:25 PM
7	also remotely via GUI app and web app	1/30/2018 9:49 PM
8	Its a new 8-bit MCU	1/30/2018 9:48 PM
9	Gesture, live video sensing, more	1/29/2018 11:33 PM
10	There is a command-line interface, but for developers only (not users).	1/29/2018 10:12 PM
11	Indirectly through the car's MMI	1/29/2018 9:01 PM
12	API	1/29/2018 5:33 AM
13	Via server-based telemetry, aggregation, applications and web interface.	1/28/2018 11:39 PM
14	via connected devices on a 485 bus	1/28/2018 10:06 AM
15	Engineering software	1/25/2018 7:23 PM
16	PLC touchscreen via ethernet IP	1/25/2018 2:47 PM
17	Web browser to cloud server. Our unit then gets commands from server.	1/25/2018 1:23 PM
18	Web sockets, Python scripts	1/25/2018 10:00 AM
19	IR Remote Control	1/25/2018 9:50 AM
20	Installation / set-up through a cloud based web interface	1/25/2018 12:33 AM
21	Text and email	1/24/2018 11:17 PM
22	Fieldbus	1/24/2018 10:46 PM
23	SMS	1/24/2018 10:26 PM
24	Autonomous	1/24/2018 9:47 PM
25	Via an integration SDK.	1/24/2018 6:35 AM
26	Built in indicators	1/24/2018 3:09 AM
27	human-machine wireless interface (motion, sound, tactile, sensory)	1/24/2018 3:02 AM
28	CAN requests.	1/24/2018 12:03 AM
29	remotely (MODBUS over RS-485)	1/23/2018 11:58 PM
30	Smart furniture - pairs based on chair angles	1/23/2018 9:40 PM
31	Can not say	1/23/2018 9:23 PM
32	Through an API	1/23/2018 9:06 PM
33	Car brake pedal	1/22/2018 9:13 PM
34	via Network Management System (LAN based)	1/22/2018 8:37 PM
35	Card swipe	1/22/2018 7:40 PM
36	SMS	1/22/2018 6:57 PM
37	Via software (lua)	1/22/2018 6:00 PM
38	RF	1/22/2018 4:49 PM
39	proximity / gesture control	1/22/2018 4:47 PM
40	Via a serial port	1/22/2018 4:44 PM
41	SNMP, RESTful API	1/22/2018 4:39 PM
42	DCS, PLC	1/22/2018 2:19 PM
43	one-time configuration / setup via PC app	1/22/2018 1:44 PM
44	Text display	1/22/2018 12:59 PM
45	Movement	1/22/2018 11:02 AM

46	Gestures proccessed by video analytics engine	1/22/2018 11:02 AM
47	Modbus monitoring	1/22/2018 11:01 AM
48	web browser but not embedded inside the product	1/22/2018 10:57 AM
49	Notning direct to the device, only GUI to cloud service indirectly to device	1/22/2018 10:28 AM
50	SD-card	1/19/2018 10:53 AM
51	Via custom interface	1/19/2018 9:23 AM
52	text messaging, email	1/17/2018 7:11 AM
53	Remote interaction over satellite	1/16/2018 11:05 PM
54	Web app that is cloud based	1/16/2018 10:55 PM
55	Cloud application	1/16/2018 9:28 PM
56	Sensors	1/16/2018 8:23 PM
57	Braille	1/16/2018 8:17 PM
58	Via dedicated device attached	1/16/2018 12:56 PM
59	Remote telecommands/telemetry from Ground Station	1/16/2018 11:01 AM
60	another Computer, that does provide user interaction	1/15/2018 10:02 PM
61	Via a web browser (on a site not hosted by the device)	1/15/2018 6:11 PM
62	command line interface	1/12/2018 10:22 PM
63	Via App and bluetooth	1/12/2018 4:45 PM
64	Web interface via cloud server	1/12/2018 1:43 AM
65	cellular backhaul to cloud	1/12/2018 12:11 AM
66	USB memory stick	1/11/2018 2:38 AM
67	Web interface on a server	1/10/2018 8:37 PM
68	remotely via i2c	1/10/2018 8:13 PM
69	.	1/10/2018 8:02 PM
70	Via RS-232 for calibration and adjustments only	1/10/2018 5:53 PM
71	fingerprint	1/9/2018 11:13 PM
72	Cloud based app.	1/9/2018 6:13 PM
73	Electrical Control via Digital and Analog I/O	1/9/2018 5:01 PM
74	Via a PC web browser and backend interface services	1/9/2018 4:21 PM
75	RF interface	1/9/2018 4:19 PM
76	SNMP	1/9/2018 2:59 PM
77	Cloud web application	1/9/2018 2:02 PM

Q14 Will the current project utilize machine learning (a.k.a., "AI") for any reason?

Answered: 1,696 Skipped: 7



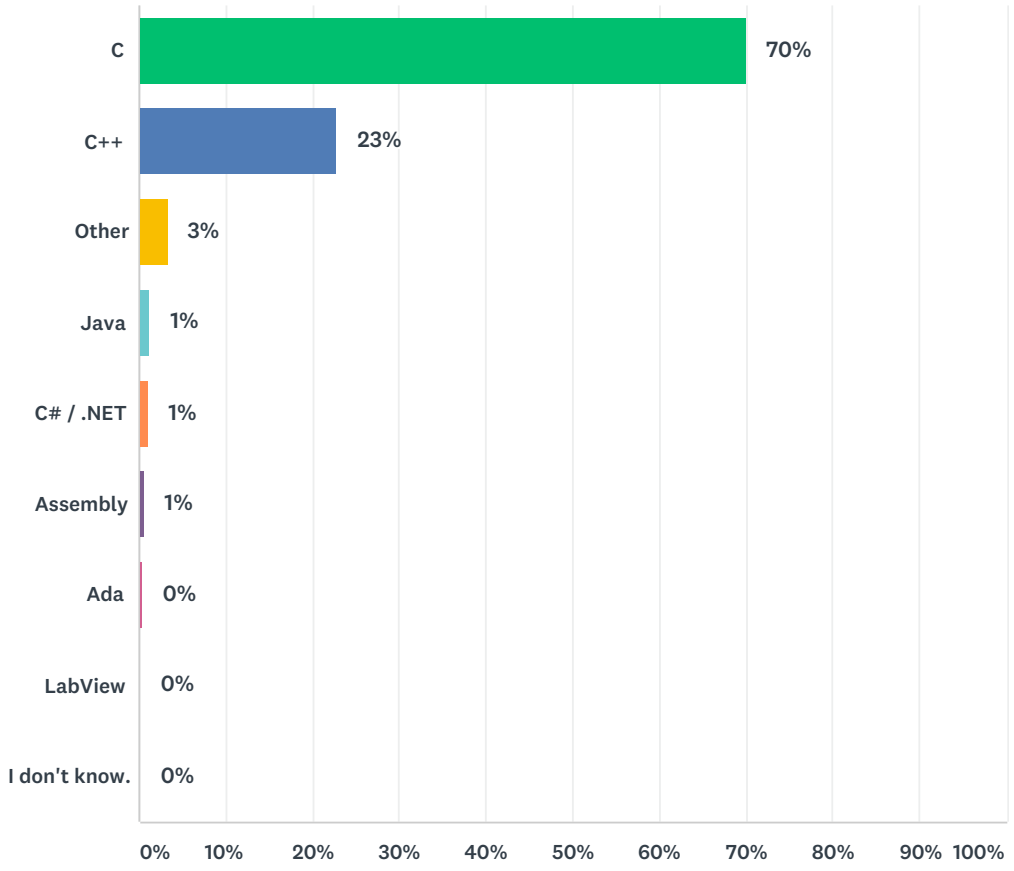
ANSWER CHOICES	RESPONSES	
No	81%	1,366
Embedded AI	6%	110
Cloud-Based AI	6%	109
I don't know.	3%	54
Design-Phase AI	2%	39
Other	1%	18
TOTAL		1,696

#	OTHER (PLEASE SPECIFY)	DATE
1	Both in embedded system and cloud - hybrid or fog computing	1/30/2018 9:54 PM
2	AI in both embedded and server/cloud locations	1/29/2018 11:33 PM
3	Machine learning for this is developed by a separate group in organization	1/25/2018 4:58 AM
4	Simple algorithm to refine available battery capacity prediction for 'minutes remaining' display	1/25/2018 12:33 AM
5	customers may use machine learning, but it isn't written by us	1/24/2018 11:18 PM
6	AI but not limited to machine learning	1/24/2018 9:47 PM
7	ML in embedded and app layers (cloud and block chain).	1/23/2018 11:07 PM
8	Can not say	1/23/2018 9:23 PM

9	Possibly	1/22/2018 7:04 PM
10	Sometime in the future, not soon	1/22/2018 6:52 PM
11	Not on this version	1/22/2018 4:00 PM
12	There are adaptive calibrations that learn the mechanical components and adjust for long term wear, but nothing that would normally be described as "AI"	1/17/2018 6:20 PM
13	Higher level classifier functions will likely use Multi-Layer-Perceptron techniques	1/17/2018 9:38 AM
14	Both on embedded and cloud	1/17/2018 6:40 AM
15	It will be on PC	1/16/2018 10:53 PM
16	We are considering using machine learning during production, but currently every behaviour is pre-programmed by humans.	1/10/2018 4:09 PM
17	We haven't decided yet, but it may be included in a future firmware release.	1/10/2018 4:09 PM
18	As of now, We didn't use ML. In the future, We will use ML.	1/10/2018 12:48 AM

Q15 What is the primary programming language for your current project?

Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
C	70%	1,192
C++	23%	390
Other	3%	56
Java	1%	22
C# / .NET	1%	17
Assembly	1%	12
Ada	0%	6
LabView	0%	4
I don't know.	0%	4
TOTAL		1,703

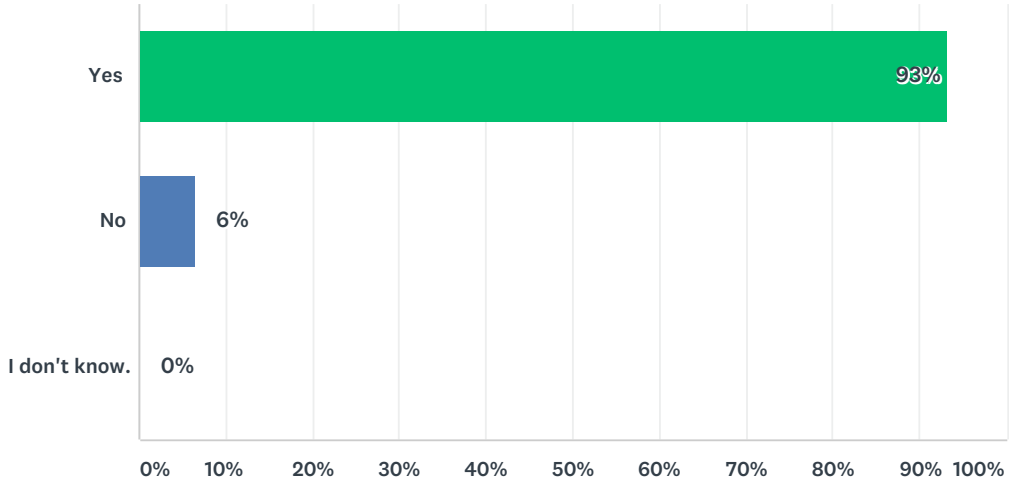
#	OTHER (PLEASE SPECIFY)	DATE
1	Ruby	2/1/2018 9:59 AM
2	v4th (Forth variant) and asm	1/31/2018 9:59 PM

3	Rust	1/30/2018 11:39 PM
4	Realtime Java (Java w/ RTSJ and deterministic GC)	1/30/2018 11:26 PM
5	Python	1/30/2018 10:01 PM
6	Swift	1/30/2018 9:58 PM
7	All of the above and anything else we need	1/30/2018 9:56 PM
8	Depending on the part of the system	1/30/2018 9:49 PM
9	ptyhon	1/29/2018 4:05 AM
10	The word "primary" sounds ambiguous to me. Measurement and manual interface in asm, network in C.	1/29/2018 1:33 AM
11	Your binary choices are too restrictive. Embedded: C, Windows C#	1/28/2018 3:24 PM
12	Structured Text	1/26/2018 5:47 PM
13	Rust	1/26/2018 10:29 AM
14	Python	1/26/2018 9:24 AM
15	Python and C	1/25/2018 1:24 PM
16	Python	1/25/2018 11:33 AM
17	C and C++	1/25/2018 9:51 AM
18	MATLAB	1/25/2018 6:01 AM
19	Pyton	1/25/2018 3:15 AM
20	C/C++	1/24/2018 8:48 PM
21	xc	1/24/2018 5:00 PM
22	Haskell, VHDL & Verilog	1/24/2018 3:53 PM
23	Simulink	1/24/2018 7:20 AM
24	Go	1/24/2018 12:35 AM
25	Python	1/23/2018 9:13 PM
26	Javascript (UI/browser development). Python second.	1/23/2018 4:59 AM
27	Python	1/23/2018 4:28 AM
28	C/C++ (about equal)	1/22/2018 7:11 PM
29	Verilog/VHDL	1/22/2018 3:49 PM
30	Matlab	1/22/2018 12:19 PM
31	Python(micropython)	1/22/2018 10:57 AM
32	Python	1/22/2018 10:43 AM
33	Forth	1/22/2018 10:30 AM
34	VHDL	1/22/2018 10:26 AM
35	Maybe Rust, but probably C	1/20/2018 10:55 PM
36	VHDL	1/19/2018 1:58 AM
37	Basic	1/17/2018 4:45 PM
38	python and C++	1/17/2018 3:32 PM
39	python	1/17/2018 7:13 AM
40	LINUX	1/17/2018 3:31 AM
41	c/masm/C++ _asm	1/17/2018 1:01 AM
42	Python	1/16/2018 10:04 PM

43	Danfoss GUIDE	1/16/2018 9:50 PM
44	Phyton	1/16/2018 8:44 PM
45	python	1/16/2018 8:28 PM
46	Free Pascal and C	1/16/2018 8:26 PM
47	Python	1/16/2018 3:06 PM
48	PLC	1/12/2018 12:43 AM
49	Matlab/Simulink/C	1/11/2018 2:49 PM
50	4DGL	1/10/2018 3:49 PM
51	Go	1/10/2018 3:43 PM
52	9	1/9/2018 8:26 PM
53	Python	1/9/2018 7:44 PM
54	Simulink	1/9/2018 7:04 PM
55	Currently Python and C++, but planning on moving to Go	1/9/2018 6:45 PM
56	Elixir	1/9/2018 2:00 PM

Q16 Does your team maintain its source code in a version control system?

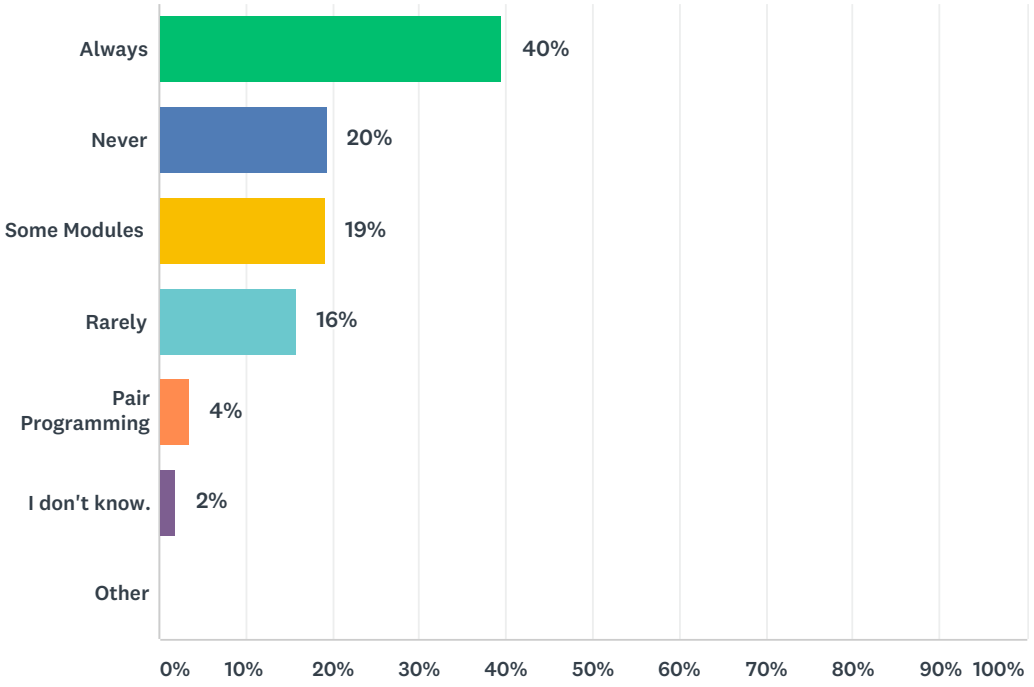
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	93%	1,588
No	6%	110
I don't know.	0%	5
TOTAL		1,703

Q17 Are peer source code reviews a part of the software development process?

Answered: 1,703 Skipped: 0

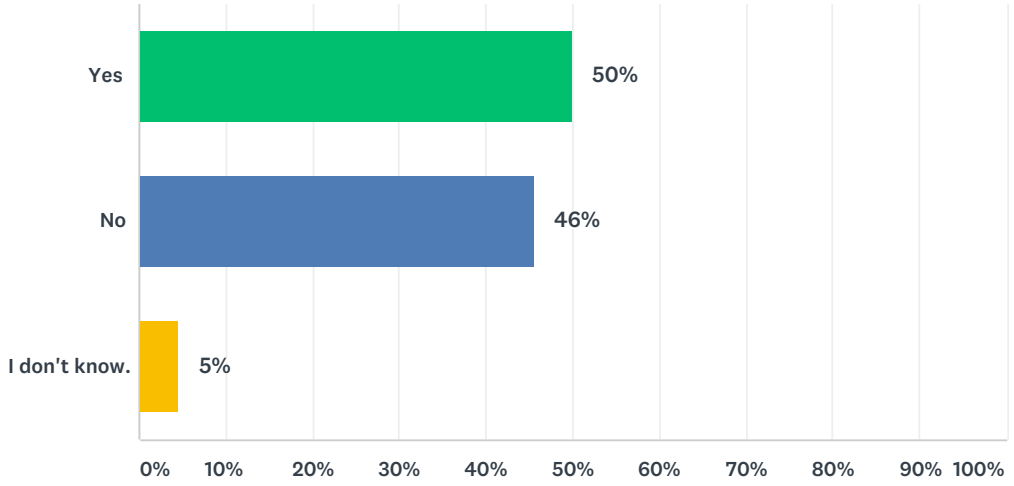


ANSWER CHOICES	RESPONSES	
Always	40%	675
Never	20%	333
Some Modules	19%	329
Rarely	16%	272
Pair Programming	4%	62
I don't know.	2%	32
Other	0%	0
TOTAL		1,703

#	OTHER (PLEASE SPECIFY)	DATE
	There are no responses.	

Q18 Is source code run through one or more static analysis tools (e.g., PC/Lint or Coverity)?

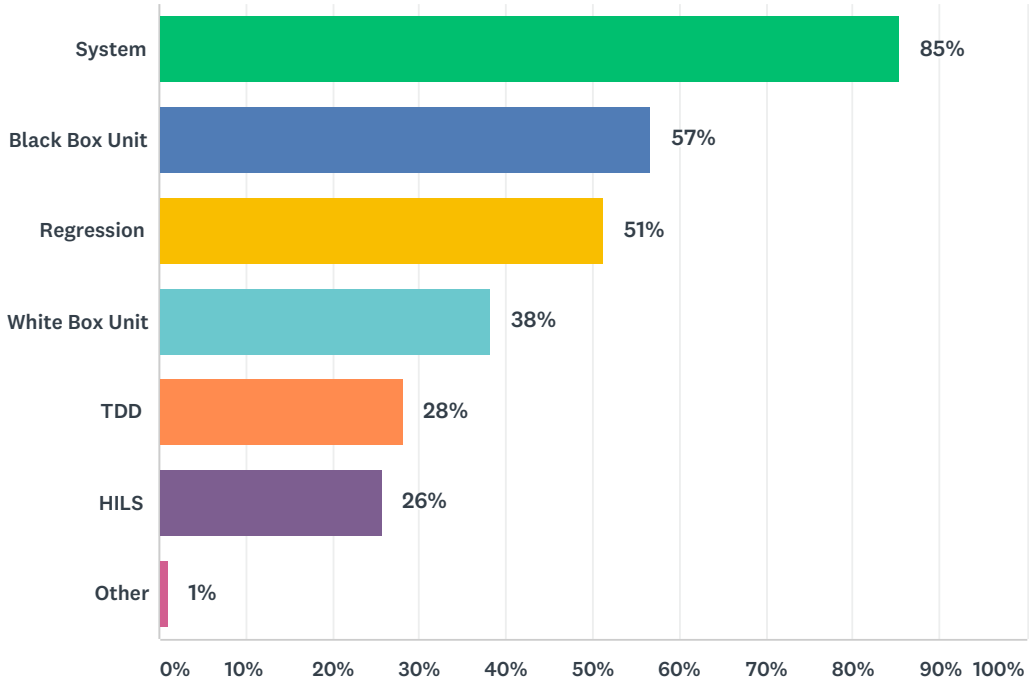
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	50%	850
No	46%	775
I don't know.	5%	78
TOTAL		1,703

Q19 If you know, what kinds of testing will be performed? (select all that apply; skip if none)

Answered: 1,644 Skipped: 59



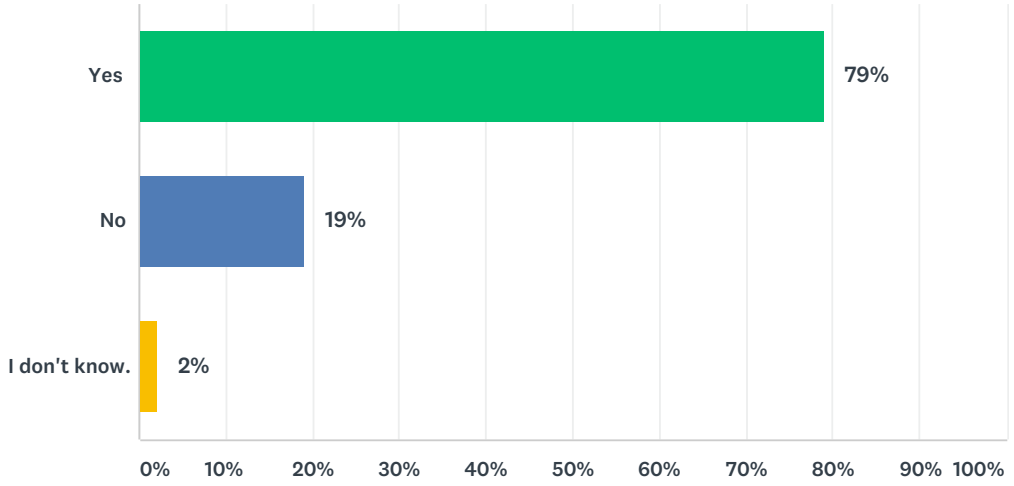
ANSWER CHOICES	RESPONSES	
System	85%	1,402
Black Box Unit	57%	931
Regression	51%	843
White Box Unit	38%	630
TDD	28%	465
HILS	26%	423
Other	1%	16
Total Respondents: 1,644		

#	OTHER (PLEASE SPECIFY)	DATE
1	HIL simulation (i.e. real control unit, simulated loads and actuators)	1/31/2018 10:16 AM
2	Started using TDD, but too much legacy code.	1/30/2018 9:51 PM
3	Model-based testing and test case generation	1/30/2018 9:49 PM
4	Simulation testing	1/25/2018 3:58 PM
5	Metrics testing	1/24/2018 9:50 PM
6	hardware simulation	1/24/2018 5:00 PM
7	Manual	1/24/2018 8:14 AM
8	Incomplete unit tests, focusing on complex modules	1/22/2018 8:45 PM

9	informal, poke it and make sure it doesn't break	1/22/2018 1:26 PM
10	System testing in simulated environment	1/16/2018 9:30 PM
11	Integration with other systems	1/16/2018 7:58 PM
12	stress testing	1/16/2018 1:19 PM
13	informal unit-level testing of new functionality as it is added	1/11/2018 2:25 PM
14	Engeneering testing. aka engeneer do random tests while developing	1/11/2018 8:36 AM
15	ad hoc	1/9/2018 6:28 PM
16	Qemu software testing	1/9/2018 5:31 PM

Q20 Are known defects formally tracked (e.g., in a bug database or issue tracking system)?

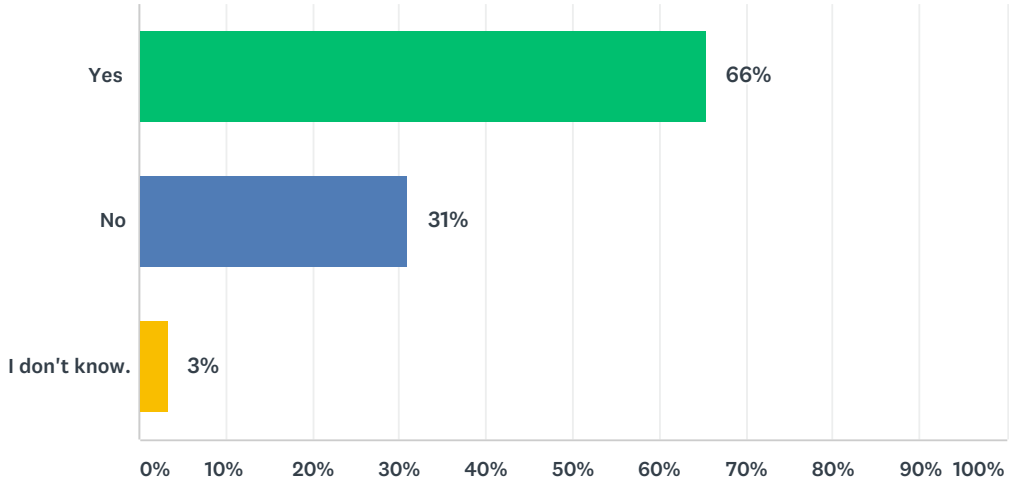
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	79%	1,346
No	19%	323
I don't know.	2%	34
TOTAL		1,703

Q21 Is there a written coding standard in place that applies to your current project?

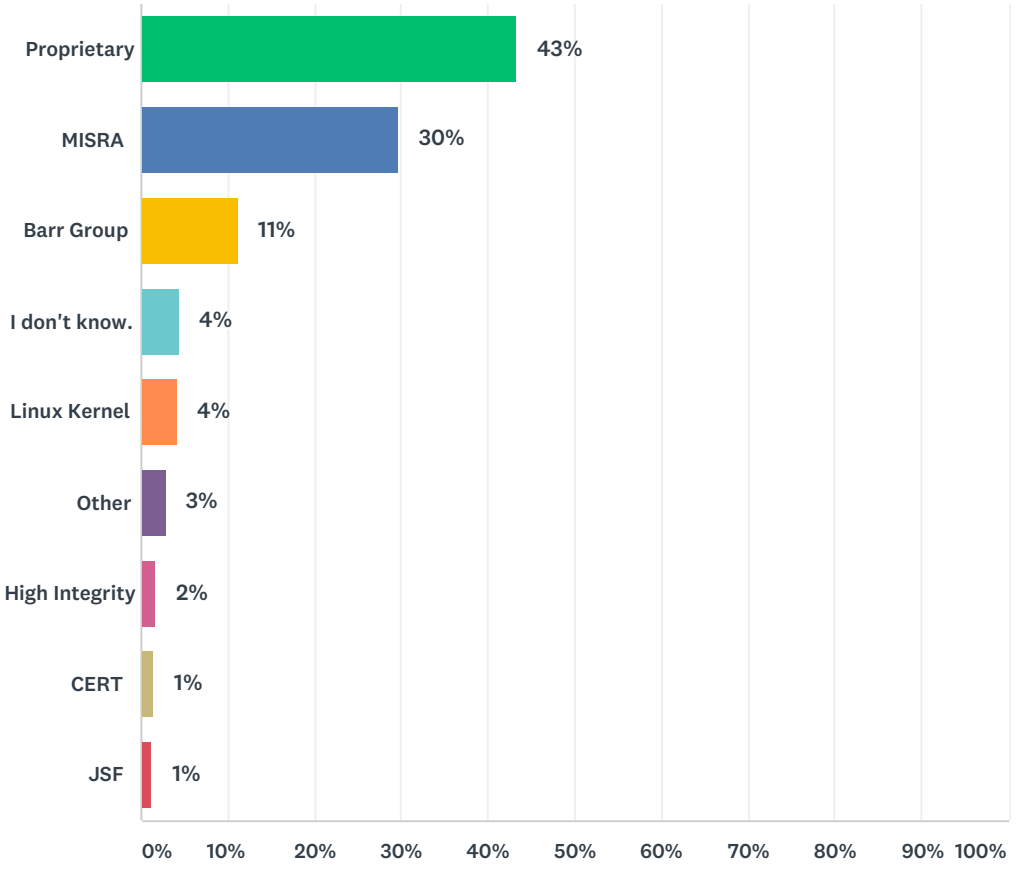
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	66%	1,116
No	31%	529
I don't know.	3%	58
TOTAL		1,703

Q22 What is the primary basis of the coding standard that applies to your current project?

Answered: 1,116 Skipped: 587



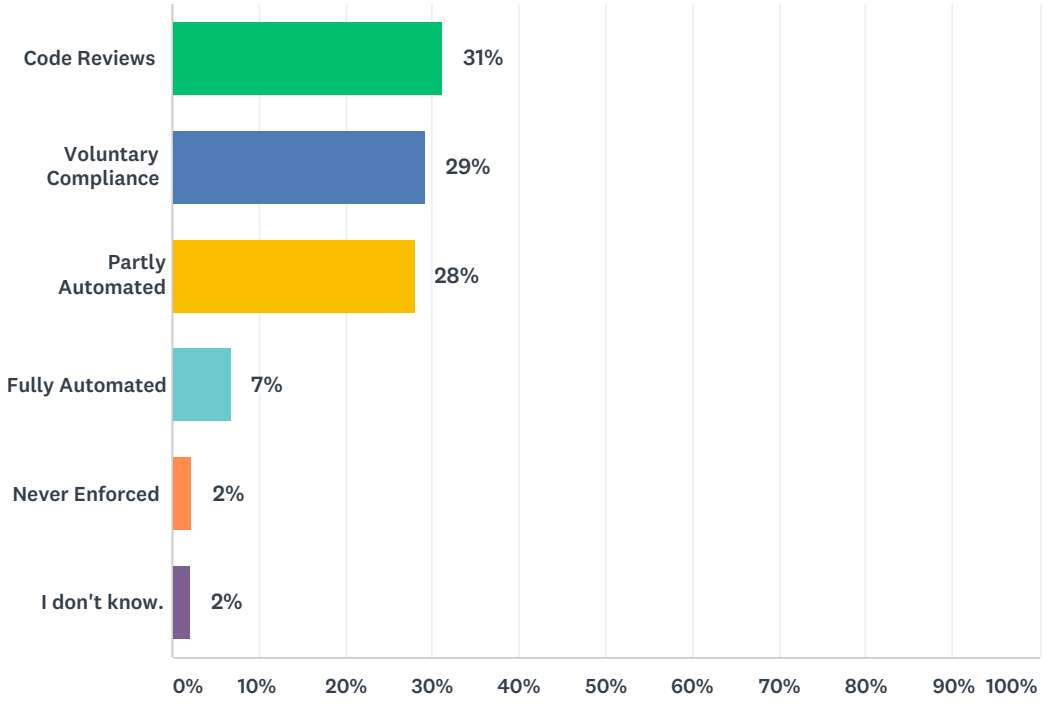
ANSWER CHOICES	RESPONSES	
Proprietary	43%	483
MISRA	30%	332
Barr Group	11%	126
I don't know.	4%	48
Linux Kernel	4%	47
Other	3%	32
High Integrity	2%	18
CERT	1%	16
JSF	1%	14
TOTAL		1,116

#	OTHER (PLEASE SPECIFY)	DATE
1	Subset of MISRA agreed across the organization	1/31/2018 4:46 AM

2	Google C++	1/30/2018 10:30 PM
3	Depends on the language.	1/30/2018 9:58 PM
4	MISRA for C firmware and custom Google style for C++	1/29/2018 3:19 PM
5	https://docs.python.org/3/tutorial/controlflow.html#intermezzo-coding-style	1/26/2018 9:27 AM
6	Ganssle with a little Barr	1/25/2018 1:27 PM
7	MISRA and Proprietary	1/25/2018 9:53 AM
8	Derived from a mix of standards for non-critical systems.	1/24/2018 10:23 PM
9	following online open source	1/24/2018 1:54 AM
10	NASA C coding Standards	1/23/2018 8:30 AM
11	google coding standard	1/23/2018 5:51 AM
12	Google's C coding standard	1/22/2018 8:46 PM
13	google c++	1/22/2018 6:02 PM
14	Jack Ganssle's Coding Standard	1/22/2018 3:11 PM
15	similar to the Barr Group's standard	1/22/2018 2:24 PM
16	MISRA but substantive changes for our environment	1/22/2018 1:47 PM
17	Industrial system c++ by ellemtel	1/22/2018 10:40 AM
18	Original Sun coding standard for Java	1/18/2018 3:03 AM
19	653	1/17/2018 3:58 AM
20	It's our own coding standard by our software architect on their previous project	1/16/2018 6:48 PM
21	Company defined Guidelines	1/16/2018 6:30 PM
22	large aerospace company with standards based on MISRA	1/13/2018 7:32 AM
23	ISO26262	1/11/2018 10:29 AM
24	google coding standard	1/10/2018 8:20 PM
25	Light weight version of the JPL flight safety coding standard	1/10/2018 4:46 PM
26	A combination of some of the above.	1/10/2018 4:11 PM
27	Power of Ten	1/10/2018 12:59 PM
28	C++ Coding Standards 101 rules, Guidelines and Best Pracrices	1/9/2018 8:16 PM
29	Pep8	1/9/2018 7:44 PM
30	GNU	1/9/2018 3:17 PM
31	DO-178	1/9/2018 2:48 PM
32	Elixir provides a coding standard and a tool to enforce it	1/9/2018 2:01 PM

Q23 How is the relevant coding standard enforced on your current project?

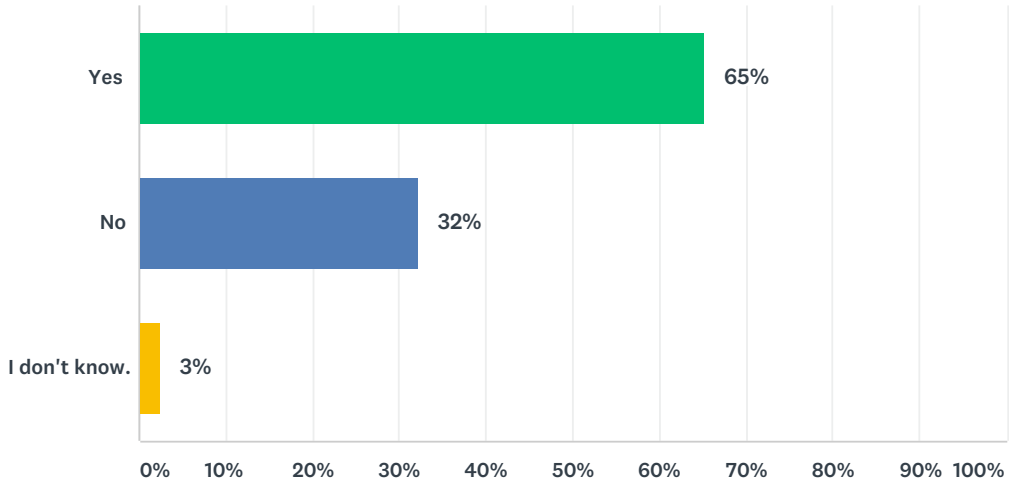
Answered: 1,116 Skipped: 587



ANSWER CHOICES	RESPONSES	
Code Reviews	31%	348
Voluntary Compliance	29%	328
Partly Automated	28%	312
Fully Automated	7%	78
Never Enforced	2%	26
I don't know.	2%	24
TOTAL		1,116

Q24 Is security one of the design considerations on your current project?

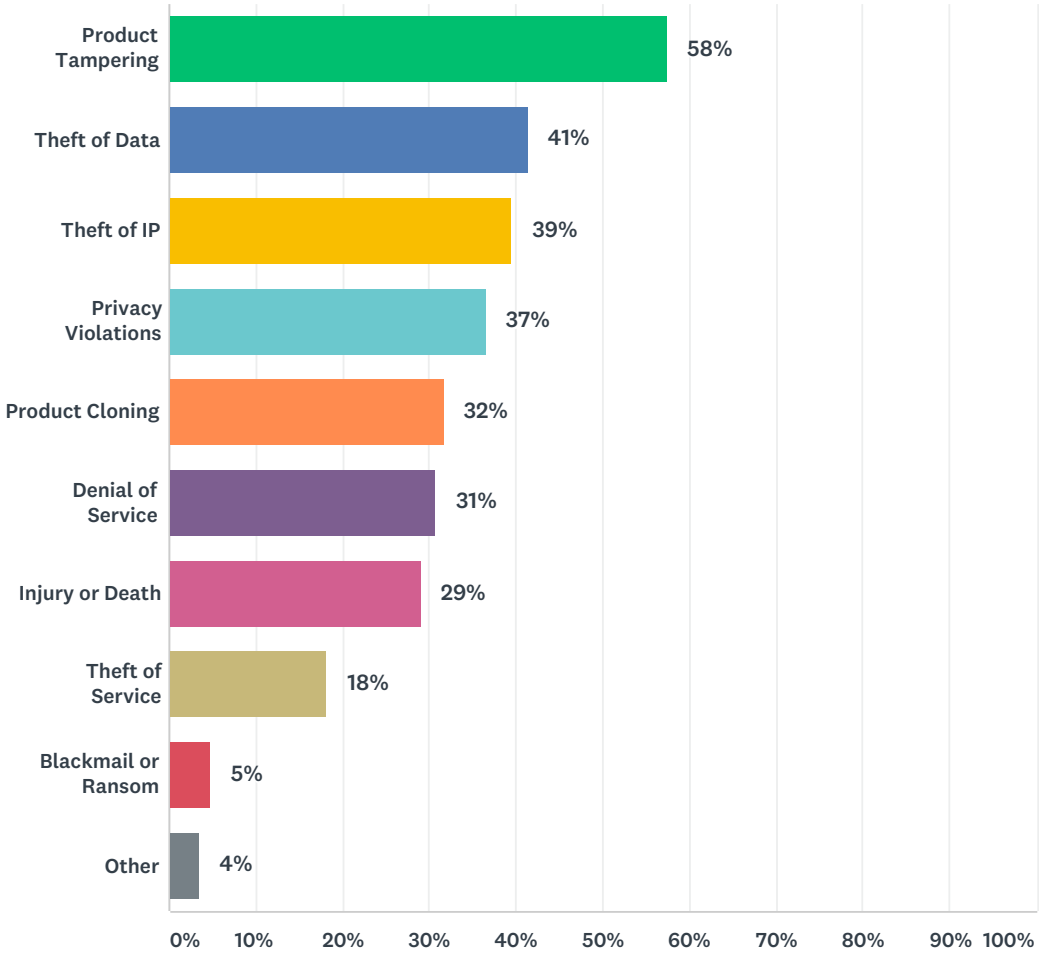
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	65%	1,112
No	32%	547
I don't know.	3%	44
TOTAL		1,703

Q25 If you know, what are the primary security concerns with your current project? (select all that apply; skip if none)

Answered: 1,074 Skipped: 629



ANSWER CHOICES	RESPONSES	
Product Tampering	58%	618
Theft of Data	41%	445
Theft of IP	39%	424
Privacy Violations	37%	393
Product Cloning	32%	342
Denial of Service	31%	330
Injury or Death	29%	312
Theft of Service	18%	195
Blackmail or Ransom	5%	51
Other	4%	38

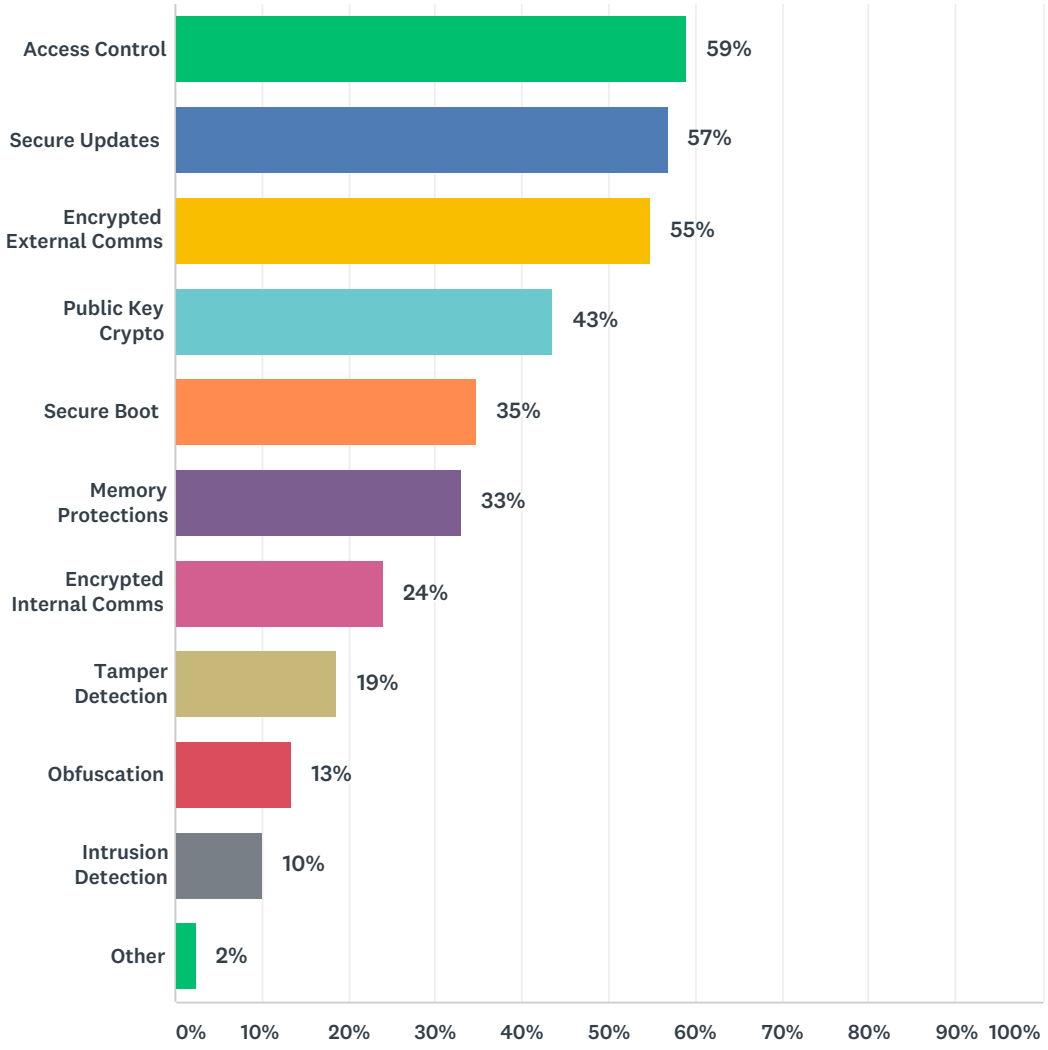
Total Respondents: 1,074

#	OTHER (PLEASE SPECIFY)	DATE
1	Theft of vehicle	1/31/2018 10:18 AM
2	device highjacking	1/30/2018 11:32 PM
3	external interference with critical systems	1/30/2018 9:53 PM
4	Poor customer satisfaction	1/29/2018 11:38 PM
5	Modification of data	1/25/2018 9:46 AM
6	The system can remotely remove power from its output, if used to power incubators / vacine fridges it could have serious consequences	1/25/2018 12:39 AM
7	Unauthorised Control of Physical Plant	1/25/2018 12:31 AM
8	Law enforcement officers are placed in danger; possible that a "bad guy" gets his case tossed.	1/24/2018 11:41 PM
9	Spoofing and false alarm prevention	1/24/2018 11:22 PM
10	Functional security	1/24/2018 9:54 PM
11	loss of product from a production process	1/24/2018 9:28 PM
12	don't know	1/23/2018 11:07 PM
13	no comment	1/23/2018 9:25 PM
14	Forcing Customer's processes to fail - espionage	1/23/2018 7:06 PM
15	Credit card fraud	1/22/2018 7:42 PM
16	Ability for competitors to support and maintain product	1/22/2018 4:26 PM
17	illicit wagering	1/22/2018 3:08 PM
18	Charging customer for non-delivered products	1/22/2018 12:49 PM
19	tampering with data	1/22/2018 12:04 PM
20	Control action integrity	1/22/2018 11:02 AM
21	No	1/22/2018 10:56 AM
22	Mainly integrity of the measured data (it's a measurement device)	1/22/2018 12:20 AM
23	unauthorized person controlling our machine remotely via Ethernet	1/18/2018 3:24 PM
24	Compliance with FIPS 140-2	1/17/2018 8:03 PM
25	It is a automation project	1/17/2018 5:32 AM
26	High Economical impact	1/16/2018 10:34 AM
27	My error: no security, only safety concerns. Security it taken care of much much higher in the system hierarchy	1/16/2018 9:53 AM
28	We don't want to be the weak link in the end users network	1/16/2018 12:48 AM
29	make sure evil doers can't hack it and break into a house	1/11/2018 1:03 AM
30	Falsification of data.	1/10/2018 10:56 PM
31	Downtime is biggest concern	1/10/2018 8:16 PM
32	manufacturing downtime	1/10/2018 4:33 PM
33	Industry compliance	1/10/2018 10:20 AM
34	Out-of-range damage.	1/9/2018 10:38 PM
35	Secuirty	1/9/2018 6:58 PM
36	DDoS, Malware, APT, threat intel, threat emulation, SOC	1/9/2018 5:35 PM
37	Safety - Damage to product or injury to user	1/9/2018 5:04 PM

38	Theft of actual product	1/9/2018 3:55 PM

Q26 If you know, which of the following security layers are used on your current project? (select all that apply; skip if none)

Answered: 1,007 Skipped: 696



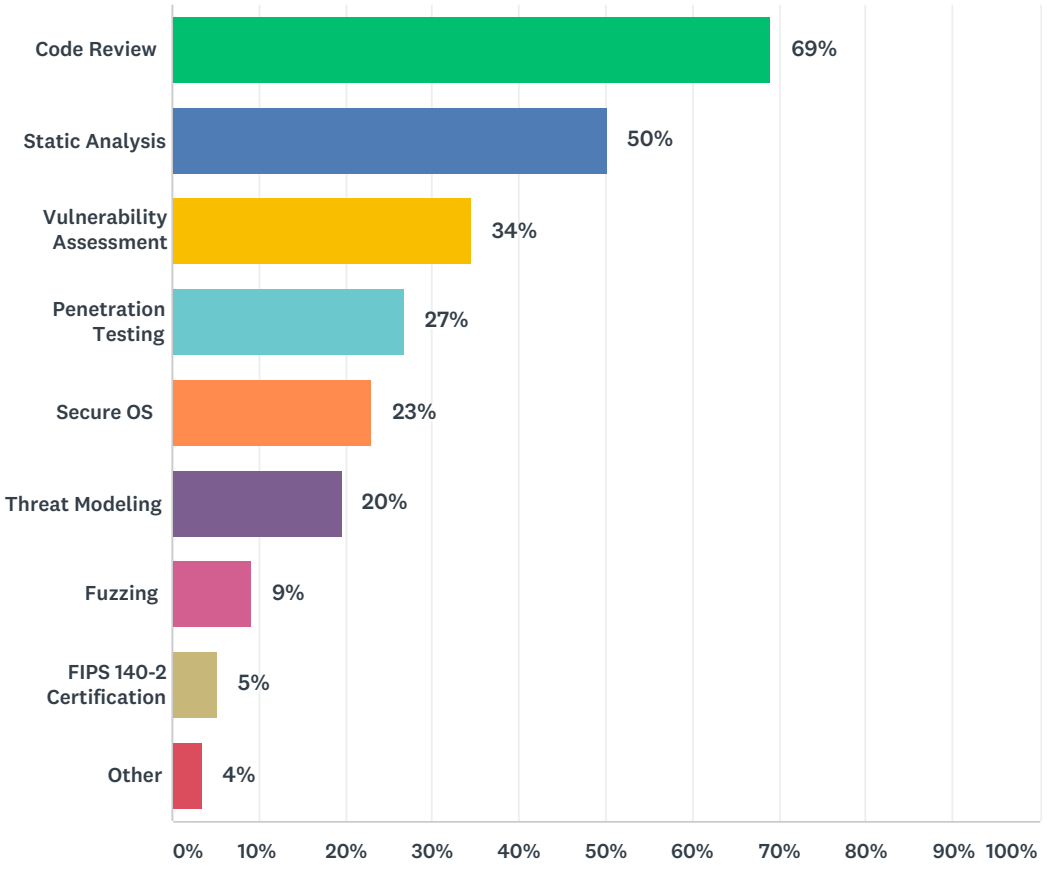
ANSWER CHOICES	RESPONSES	
Access Control	59%	594
Secure Updates	57%	574
Encrypted External Comms	55%	551
Public Key Crypto	43%	438
Secure Boot	35%	349
Memory Protections	33%	332
Encrypted Internal Comms	24%	242
Tamper Detection	19%	188
Obfuscation	13%	134

Intrusion Detection	10%	101
Other	2%	25
Total Respondents: 1,007		

#	OTHER (PLEASE SPECIFY)	DATE
1	Can't answer	1/31/2018 3:55 AM
2	Secure module update and replacement	1/30/2018 11:32 PM
3	I am not aware of all of the steps taken personally.	1/29/2018 11:38 PM
4	Measured Boot	1/25/2018 3:50 PM
5	none	1/25/2018 2:51 PM
6	DoS	1/25/2018 8:53 AM
7	No sure	1/25/2018 6:34 AM
8	.	1/25/2018 6:32 AM
9	Limit Functionality out-of-the-box. User needs to enable insecure features	1/25/2018 12:31 AM
10	limited connection, data output only	1/24/2018 3:55 PM
11	don't know	1/23/2018 11:07 PM
12	no comment	1/23/2018 9:25 PM
13	Network isolation	1/23/2018 8:50 PM
14	None of your business.	1/22/2018 6:55 PM
15	Net work security will be handled by an external device as required.	1/22/2018 11:02 AM
16	http://www.prosefights.org/malwaretips/p022415/haxrootrap.mp3	1/17/2018 1:09 AM
17	MCU Lock bits	1/16/2018 10:58 PM
18	Hardware root of trust	1/16/2018 8:33 PM
19	not sure	1/16/2018 8:24 PM
20	Sorry	1/16/2018 8:00 PM
21	.	1/10/2018 8:04 PM
22	Use of a TPM chip.	1/10/2018 7:15 PM
23	Cannot give information on security	1/10/2018 6:08 PM
24	Detection and logging of power failure and communications interruption	1/10/2018 3:36 PM
25	firewall	1/9/2018 1:38 PM

Q27 If you know, which of the following processes are used to increase security on your current project? (select all that apply; skip if none)

Answered: 790 Skipped: 913



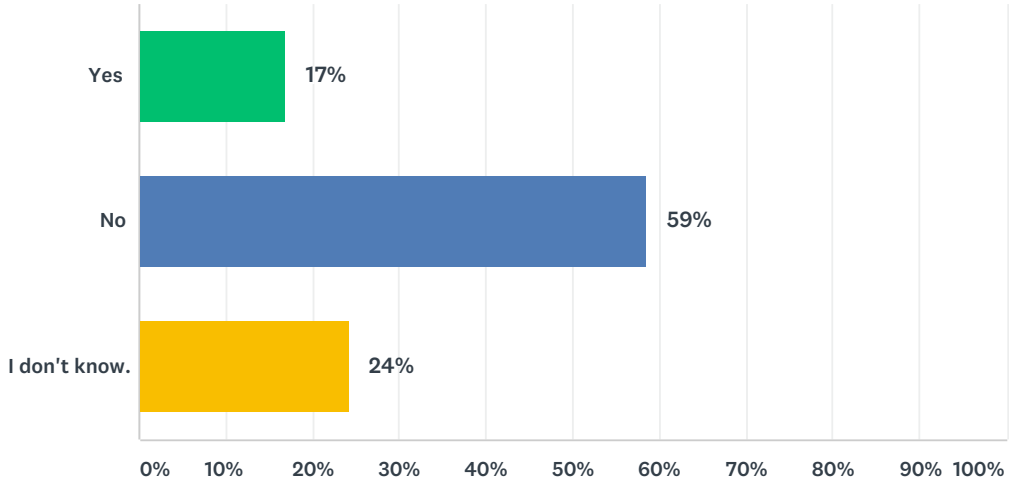
ANSWER CHOICES	RESPONSES	
Code Review	69%	546
Static Analysis	50%	396
Vulnerability Assessment	34%	272
Penetration Testing	27%	212
Secure OS	23%	182
Threat Modeling	20%	155
Fuzzing	9%	73
FIPS 140-2 Certification	5%	41
Other	4%	28
Total Respondents: 790		

#	OTHER (PLEASE SPECIFY)	DATE

1	Can't answer	1/31/2018 3:55 AM
2	Unique Device Certificates, TPM	1/30/2018 11:32 PM
3	Common sense and applying best practices in architectural design.	1/30/2018 10:01 PM
4	I do not know	1/29/2018 11:38 PM
5	DoS	1/25/2018 8:53 AM
6	.	1/25/2018 6:32 AM
7	Automatic alarms	1/24/2018 11:22 PM
8	Custom microcontroller	1/24/2018 3:55 PM
9	don't know	1/23/2018 11:07 PM
10	no comment	1/23/2018 9:25 PM
11	None of your business.	1/22/2018 6:55 PM
12	nothing as formal as these - we need to improve	1/22/2018 5:29 PM
13	ISO 26262	1/22/2018 5:23 PM
14	Design for Security	1/22/2018 2:21 PM
15	check integrity	1/22/2018 11:49 AM
16	None	1/22/2018 10:57 AM
17	No solution? Hackers win?	1/17/2018 1:09 AM
18	not sure	1/16/2018 8:24 PM
19	?	1/16/2018 12:31 PM
20	Device write only protection	1/15/2018 7:08 PM
21	ASIL compliance	1/11/2018 7:20 AM
22	.	1/10/2018 8:04 PM
23	HIgh Level Layer Encryption	1/10/2018 6:59 PM
24	Cannot give information on security	1/10/2018 6:08 PM
25	None.	1/10/2018 4:29 PM
26	Achilles DNS testing	1/10/2018 10:20 AM
27	proprietary	1/9/2018 6:29 PM
28	Independent testing house	1/9/2018 5:34 PM

Q28 Will your team hire any outside security experts to help increase the security of the final product?

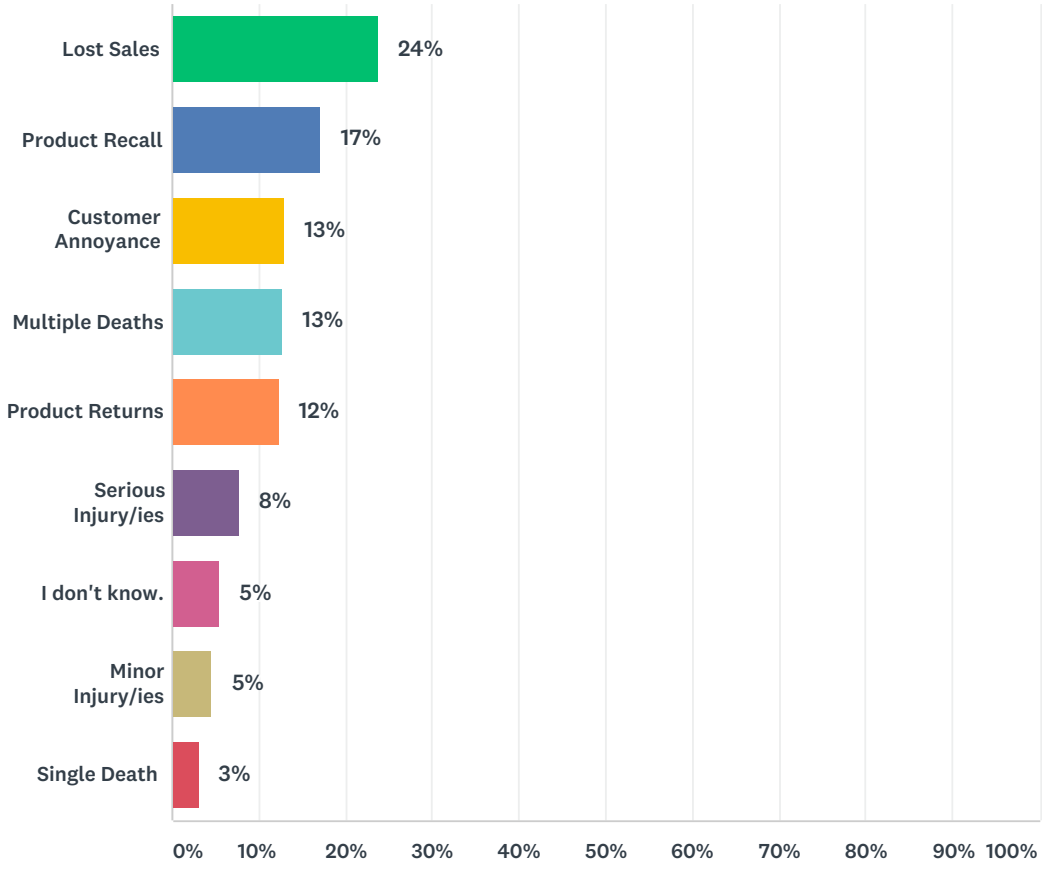
Answered: 1,105 Skipped: 598



ANSWER CHOICES	RESPONSES	
Yes	17%	188
No	59%	648
I don't know.	24%	269
TOTAL		1,105

Q29 If the product resulting from your current project malfunctioned, what is the worst possible outcome?

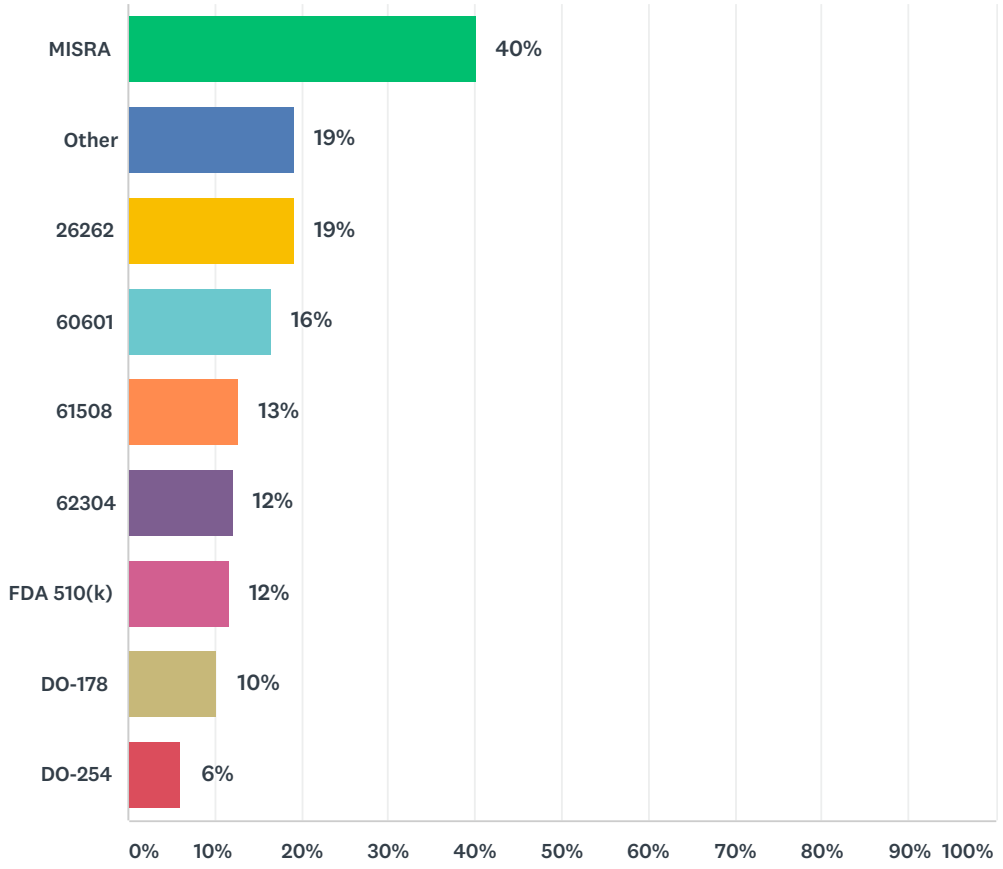
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
Lost Sales	24%	406
Product Recall	17%	291
Customer Annoyance	13%	220
Multiple Deaths	13%	219
Product Returns	12%	211
Serious Injury/ies	8%	132
I don't know.	5%	93
Minor Injury/ies	5%	78
Single Death	3%	53
TOTAL		1,703

Q30 If you know, with which of the following safety standards is the product intended to comply? (select all that apply; skip if none)

Answered: 637 Skipped: 1,066



ANSWER CHOICES	RESPONSES	
MISRA	40%	256
Other	19%	123
26262	19%	122
60601	16%	105
61508	13%	81
62304	12%	77
FDA 510(k)	12%	74
DO-178	10%	65
DO-254	6%	38
Total Respondents: 637		

#	OTHER (PLEASE SPECIFY)	DATE
1	50126, 50128, 50129	1/31/2018 10:03 PM

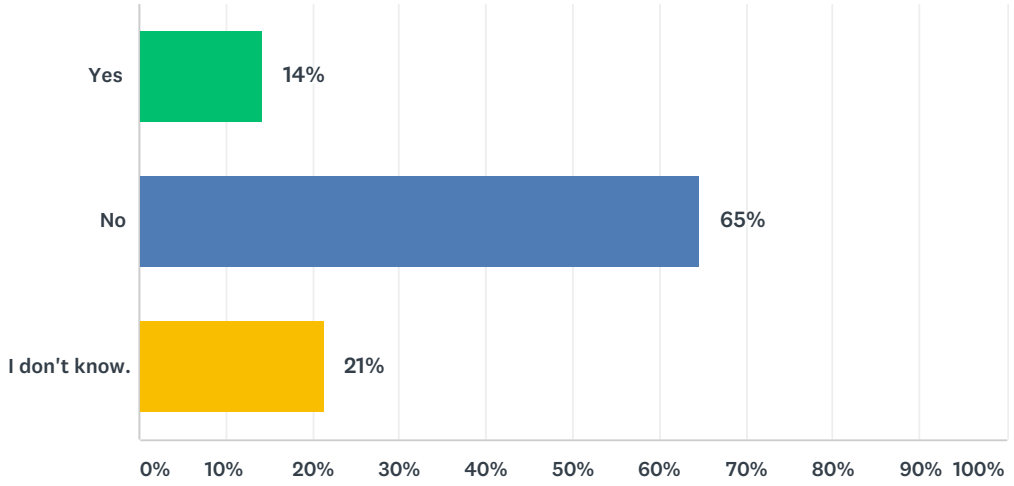
2	60079-11	1/31/2018 6:33 PM
3	Industry specific IEC standard	1/31/2018 2:34 PM
4	Iso9000?	1/31/2018 12:19 PM
5	-	1/31/2018 10:51 AM
6	Don't know	1/31/2018 8:48 AM
7	ISO/IEC 9126, UNE-EN 50126, UNE-EN 50128, UNE-EN 50129	1/31/2018 8:31 AM
8	i don't know	1/31/2018 6:36 AM
9	none	1/31/2018 6:11 AM
10	60335	1/30/2018 11:41 PM
11	UL858, IEC60730	1/30/2018 11:36 PM
12	Don't know	1/30/2018 10:14 PM
13	MIL-STD 882E	1/30/2018 10:04 PM
14	61511	1/30/2018 9:55 PM
15	25119 (derivative of 61508 for farming equipment)	1/30/2018 9:51 PM
16	Worldwide Hazardous Location certifications: CSA, UL, ATEX, IECEx	1/30/2018 9:48 PM
17	None	1/30/2018 9:46 PM
18	DNV GL	1/30/2018 9:39 PM
19	50128	1/30/2018 9:27 AM
20	Others may apply.	1/29/2018 11:39 PM
21	UL,CSA	1/29/2018 3:09 PM
22	EN 137	1/26/2018 10:34 AM
23	61131, 61158	1/25/2018 10:04 AM
24	IEC 60730, IEC 60335, UL1017, UL2595 and others	1/25/2018 9:56 AM
25	60335	1/25/2018 7:56 AM
26	61010	1/25/2018 6:52 AM
27	ISO/PAS 21448	1/25/2018 3:44 AM
28	61010	1/24/2018 11:38 PM
29	IEC 60730 - 1 Annex H	1/24/2018 10:09 PM
30	We are developing ISA and support tools our customers will uses combinations od the above	1/24/2018 9:56 PM
31	We have one board in system that follows UL guidelines for boiler ignition, but I don't remember which ones (not involved in that part of project).	1/24/2018 9:55 PM
32	MIL-STD-883	1/24/2018 9:41 PM
33	STIG	1/24/2018 9:03 PM
34	61010	1/24/2018 8:52 PM
35	50128	1/24/2018 5:43 PM
36	FDA class 1, IEC class 1M	1/24/2018 12:11 PM
37	60335	1/24/2018 10:49 AM
38	Prototype development	1/24/2018 10:01 AM
39	Don't know	1/24/2018 8:18 AM
40	13849	1/24/2018 8:03 AM
41	none	1/24/2018 6:34 AM

42	FSMA and European equivalent standards.	1/23/2018 11:12 PM
43	don't know	1/23/2018 11:09 PM
44	I don't know these standatrds	1/23/2018 10:40 PM
45	Hi	1/23/2018 10:09 PM
46	Don't know	1/23/2018 9:28 PM
47	no comment	1/23/2018 9:26 PM
48	we use MISRA to improve code quality but it's not a formal requirement	1/23/2018 9:29 AM
49	Dont know	1/23/2018 8:34 AM
50	none until forced to by the feds	1/23/2018 1:05 AM
51	Not at liberty to say	1/22/2018 9:57 PM
52	Varies	1/22/2018 6:56 PM
53	60730-2-5	1/22/2018 5:54 PM
54	usually just UL/CE for power distribution	1/22/2018 4:52 PM
55	UL	1/22/2018 4:50 PM
56	14971	1/22/2018 4:09 PM
57	60730	1/22/2018 3:52 PM
58	60730	1/22/2018 3:40 PM
59	60730	1/22/2018 2:10 PM
60	None	1/22/2018 1:02 PM
61	Inhouse	1/22/2018 12:25 PM
62	IEC 62061, ISO 13849, ISO 14119	1/22/2018 11:53 AM
63	None	1/22/2018 11:13 AM
64	50128	1/22/2018 10:28 AM
65	MILITARY STANDARDS	1/22/2018 6:41 AM
66	UL1998 / UL60730	1/20/2018 2:55 PM
67	don't know	1/19/2018 5:59 AM
68	jsf-av	1/18/2018 6:20 PM
69	ISO13485:2016	1/18/2018 9:56 AM
70	ATEX	1/18/2018 7:47 AM
71	50128	1/18/2018 7:47 AM
72	EN 50126, 50128, 50129	1/17/2018 8:19 AM
73	functional safety standard	1/17/2018 5:04 AM
74	Hackers win? http://www.prosefights.org/malwaretips/haxroot.htm	1/17/2018 1:12 AM
75	None	1/16/2018 10:59 PM
76	13849	1/16/2018 10:25 PM
77	Ansi	1/16/2018 9:52 PM
78	UL 1069	1/16/2018 9:39 PM
79	EDSA	1/16/2018 8:29 PM
80	FCC	1/16/2018 8:28 PM
81	None	1/16/2018 8:00 PM
82	I don't know	1/16/2018 6:51 PM

83	UL 2054	1/16/2018 3:24 PM
84	don't know	1/16/2018 3:02 PM
85	EN50128	1/16/2018 12:45 PM
86	IEC 61131	1/16/2018 11:09 AM
87	ECSS-Q-ST-80C	1/16/2018 11:05 AM
88	UL1010,UL950,EN1010,EN950	1/15/2018 10:47 PM
89	EN45014, ISO/IEC Guide 22, IEC60825-1, and others	1/15/2018 7:18 PM
90	IEC60335-1	1/15/2018 7:14 PM
91	61010	1/15/2018 5:17 PM
92	IEC 62133	1/11/2018 11:43 PM
93	UL 1998	1/11/2018 8:22 PM
94	ISO 25119	1/11/2018 2:31 PM
95	IEC 60079-29-1, EN 50271	1/11/2018 1:30 PM
96	Safety is handled by external HW, developed by another project	1/11/2018 8:38 AM
97	none	1/11/2018 1:42 AM
98	UL	1/11/2018 1:27 AM
99	as3000, as61950	1/11/2018 12:04 AM
100	60730	1/10/2018 8:57 PM
101	None	1/10/2018 6:38 PM
102	13485	1/10/2018 6:37 PM
103	60335	1/10/2018 6:22 PM
104	I don't know	1/10/2018 5:31 PM
105	Pick and place machine safety	1/10/2018 4:05 PM
106	ISO 25119	1/10/2018 4:01 PM
107	60730	1/10/2018 3:58 PM
108	RSTRAT Cert.	1/10/2018 3:48 PM
109	61010	1/10/2018 1:35 AM
110	iso-13485	1/10/2018 1:31 AM
111	rail industry standards (european)	1/9/2018 9:02 PM
112	HFEA	1/9/2018 6:29 PM
113	ISO/TS 15066	1/9/2018 6:15 PM
114	none	1/9/2018 5:34 PM
115	13849	1/9/2018 5:05 PM
116	ISO 13485	1/9/2018 5:02 PM
117	Not sure	1/9/2018 4:18 PM
118	EN-15194	1/9/2018 3:58 PM
119	60335	1/9/2018 2:34 PM
120	AS 4509	1/9/2018 2:32 PM
121	NDA	1/9/2018 1:59 PM
122	none of the above	1/9/2018 1:56 PM
123	No standard	1/8/2018 11:37 PM

Q31 Will your team hire any outside experts to help increase the safety or reliability of the product?

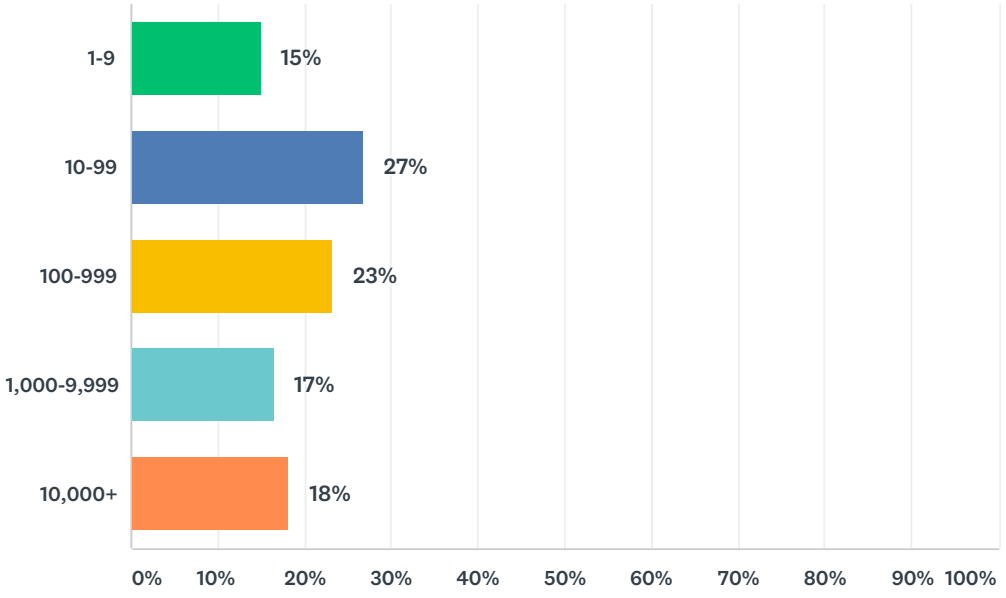
Answered: 1,690 Skipped: 13



ANSWER CHOICES	RESPONSES	
Yes	14%	239
No	65%	1,091
I don't know.	21%	360
TOTAL		1,690

Q32 Approximately how many total people work at your company (across all locations)?

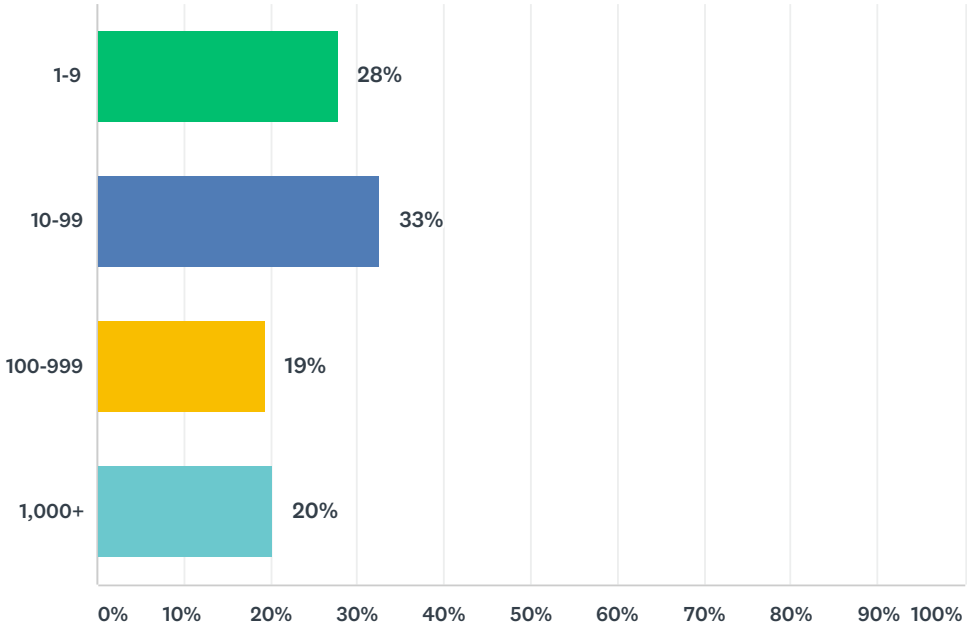
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
1-9	15%	252
10-99	27%	447
100-999	23%	386
1,000-9,999	17%	276
10,000+	18%	304
TOTAL		1,665

Q33 Approximately how many engineers (of any type) work at the company?

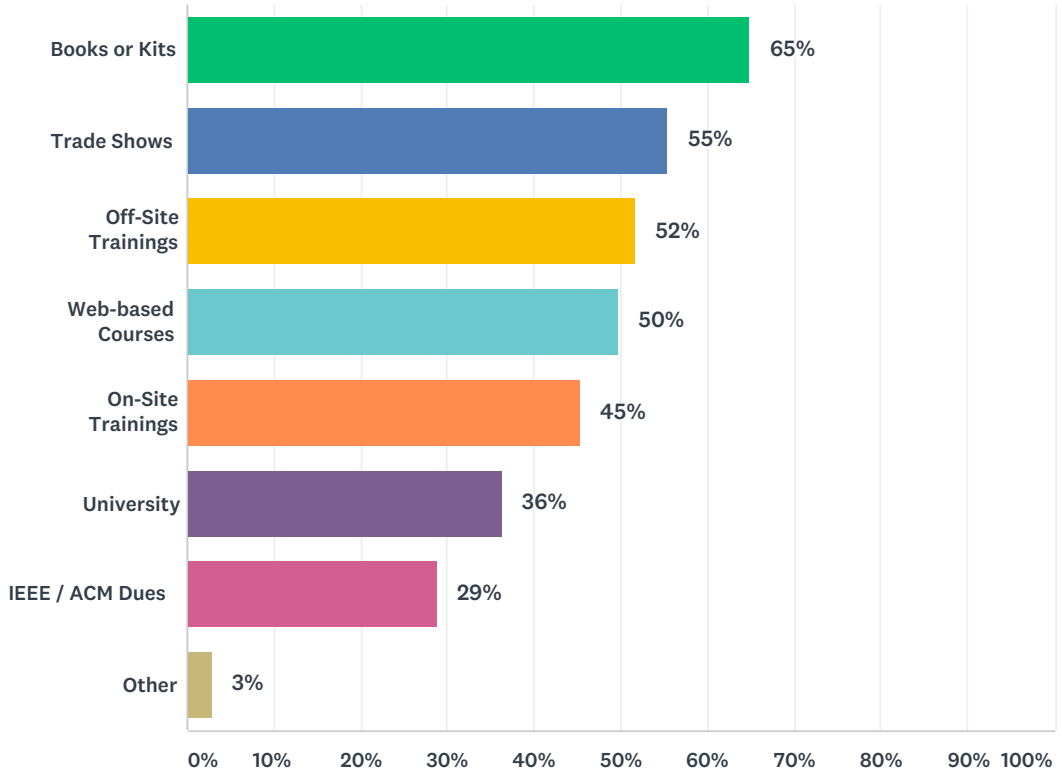
Answered: 1,703 Skipped: 0



ANSWER CHOICES	RESPONSES	
1-9	28%	456
10-99	33%	535
100-999	19%	318
1,000+	20%	333
TOTAL		1,642

Q34 If you know, what methods of career skills development does your company pay for with respect to its engineers? (select all that apply; skip if none)

Answered: 1,365 Skipped: 338



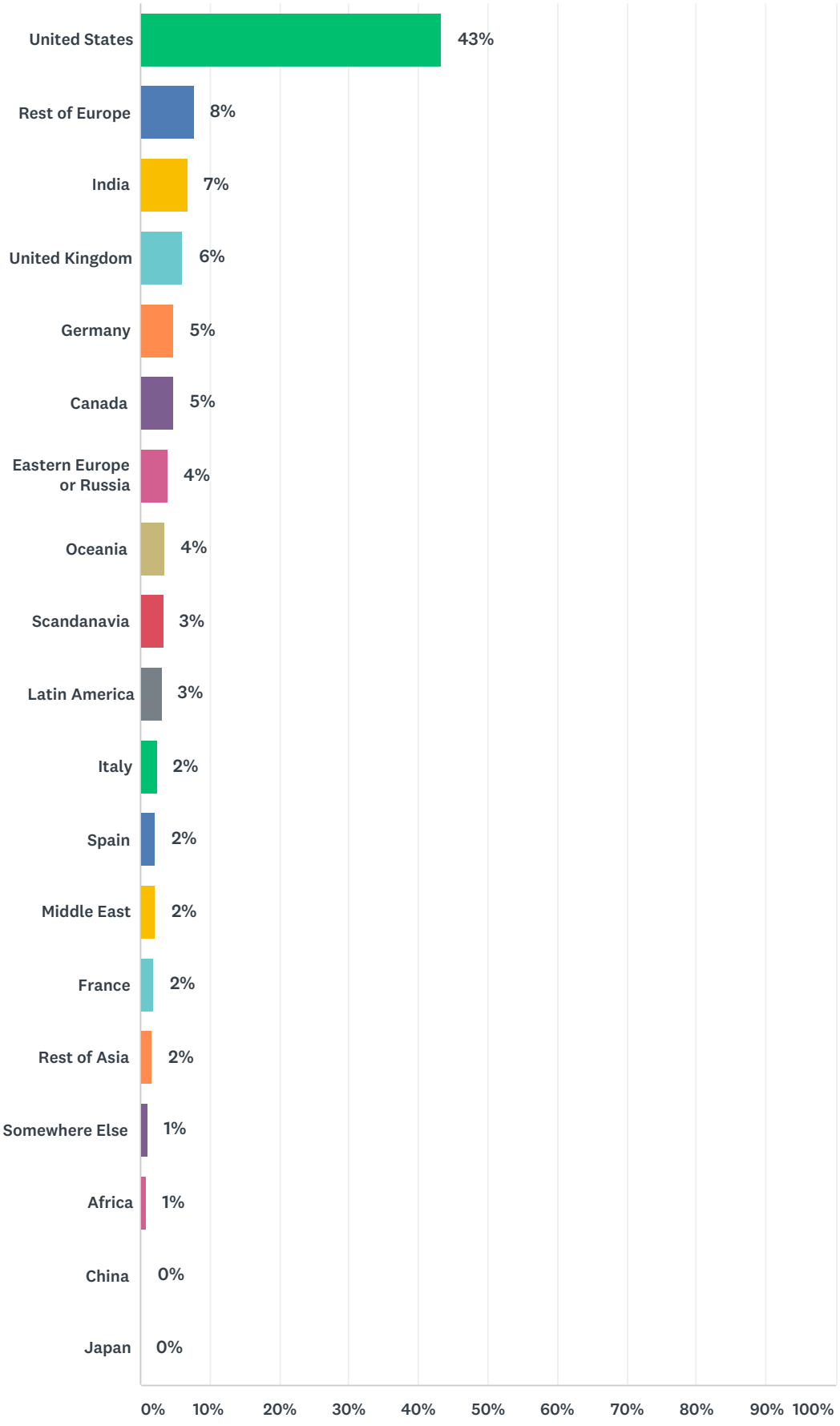
ANSWER CHOICES	RESPONSES	
Books or Kits	65%	884
Trade Shows	55%	757
Off-Site Trainings	52%	704
Web-based Courses	50%	679
On-Site Trainings	45%	620
University	36%	496
IEEE / ACM Dues	29%	394
Other	3%	39
Total Respondents: 1,365		

#	OTHER (PLEASE SPECIFY)	DATE
1	Never time for skill development. Difficult to get such expenses approved.	1/30/2018 9:54 PM
2	Internal development programs	1/30/2018 9:52 PM
3	NONE	1/30/2018 8:03 PM

4	Internet study / research	1/29/2018 3:49 PM
5	I have my own IEEE membership	1/28/2018 3:27 PM
6	none - it expects engineers to train themselves	1/25/2018 10:18 AM
7	reference material and standards	1/24/2018 9:58 PM
8	Independent consultant - on my own	1/24/2018 9:29 PM
9	internal trainings	1/24/2018 9:13 PM
10	Internal training	1/24/2018 8:56 PM
11	none	1/24/2018 8:54 PM
12	I'm the owner and 1 employee, whatever I can find time and money for!	1/22/2018 7:01 PM
13	Company can't be bothered to support its engineers.	1/22/2018 6:45 PM
14	trade shows and paid training courses on a case by case basis	1/22/2018 4:55 PM
15	Internal training by internal subject matter experts	1/22/2018 2:22 PM
16	No much training	1/22/2018 1:33 PM
17	U	1/22/2018 12:55 PM
18	Self-directed learning on paid time	1/22/2018 10:38 AM
19	training budget is extremely limited	1/18/2018 3:54 PM
20	If you bleat til you're blue in the face you might get some time allocated to learn relevant new stuff.	1/17/2018 9:42 AM
21	None	1/17/2018 5:58 AM
22	Internal training by internal expert	1/17/2018 2:13 AM
23	https://www.google.com/search?q=embedded+controller+forth+for+the+8051+family&rlz=1C1CHBF_enUS756US756&oq=embedd+controller+for+the+&aqs=chrome.1.69i57j0.14238j1j7&sourceid=chrome&ie=UTF-8	1/17/2018 1:16 AM
24	none	1/16/2018 10:14 PM
25	Academic conferences	1/16/2018 11:08 AM
26	We are expected to get training on our own-- so, free only for me...	1/16/2018 4:05 AM
27	We have our own University in house	1/15/2018 5:23 PM
28	no	1/11/2018 10:48 AM
29	mostly internally conducted training	1/11/2018 1:27 AM
30	Sole-proprietor consultant - I pay for any/all of the above.	1/10/2018 4:03 PM
31	on-site knowledge sharing sessions and training	1/10/2018 3:59 PM
32	single person company	1/10/2018 3:45 PM
33	Online courses primarily from MIT	1/9/2018 11:21 PM
34	None	1/9/2018 4:23 PM
35	internally developed web-based training	1/9/2018 3:36 PM
36	None	1/9/2018 2:45 PM
37	None	1/9/2018 2:03 PM
38	NDA	1/9/2018 1:59 PM
39	dont know	1/9/2018 1:42 PM

Q35 In which country or region do you currently reside?

Answered: 1,699 Skipped: 4

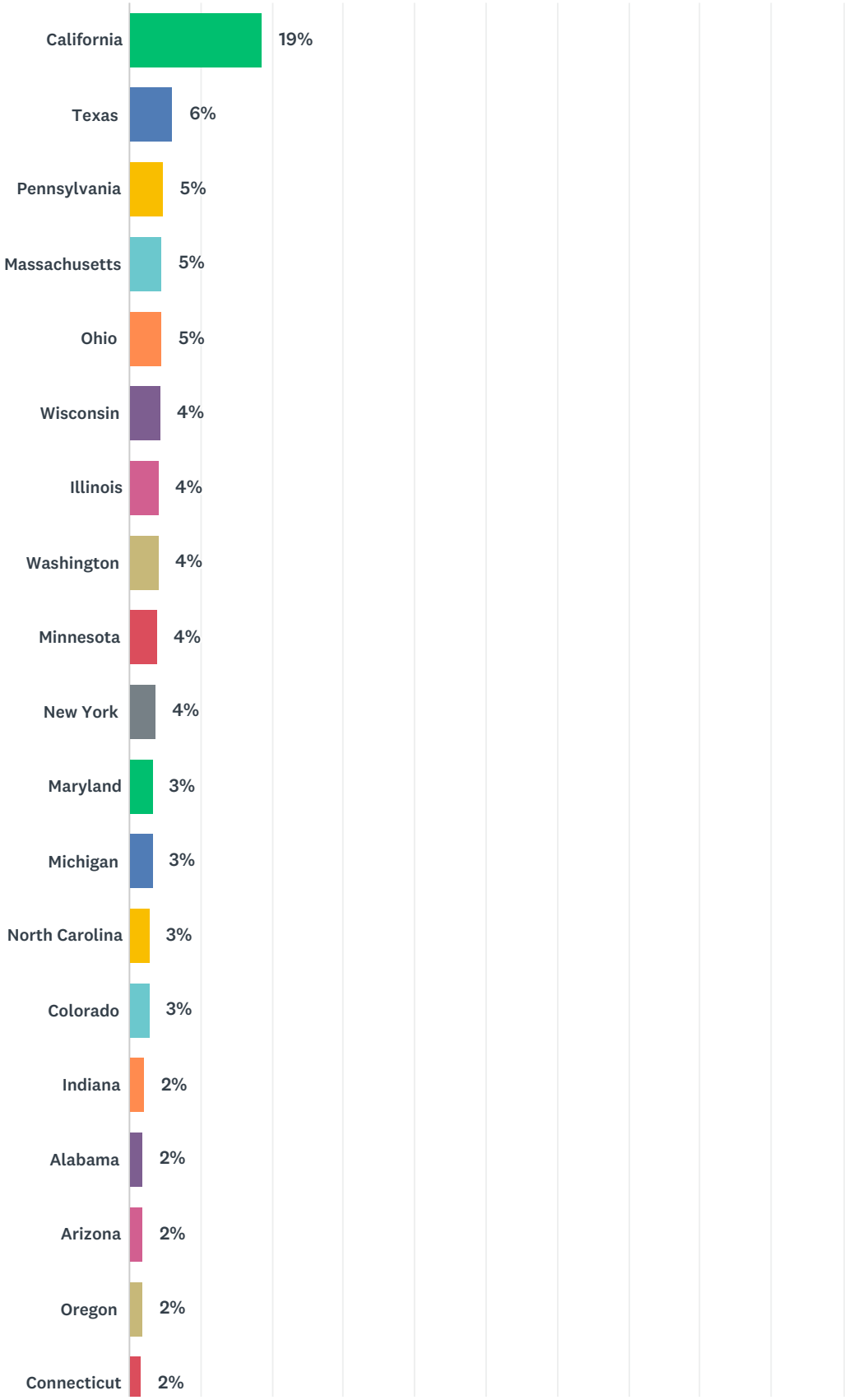


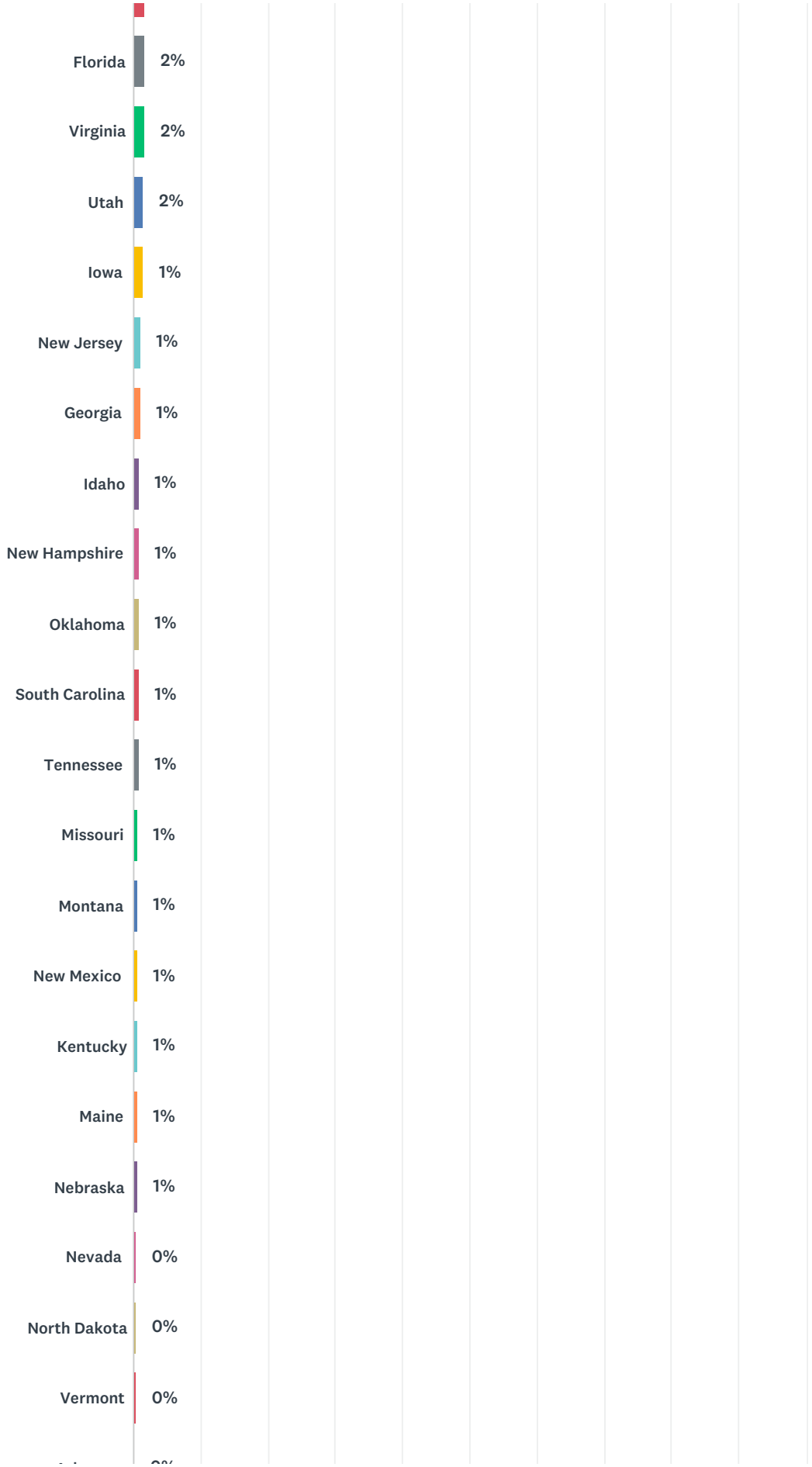
ANSWER CHOICES	RESPONSES

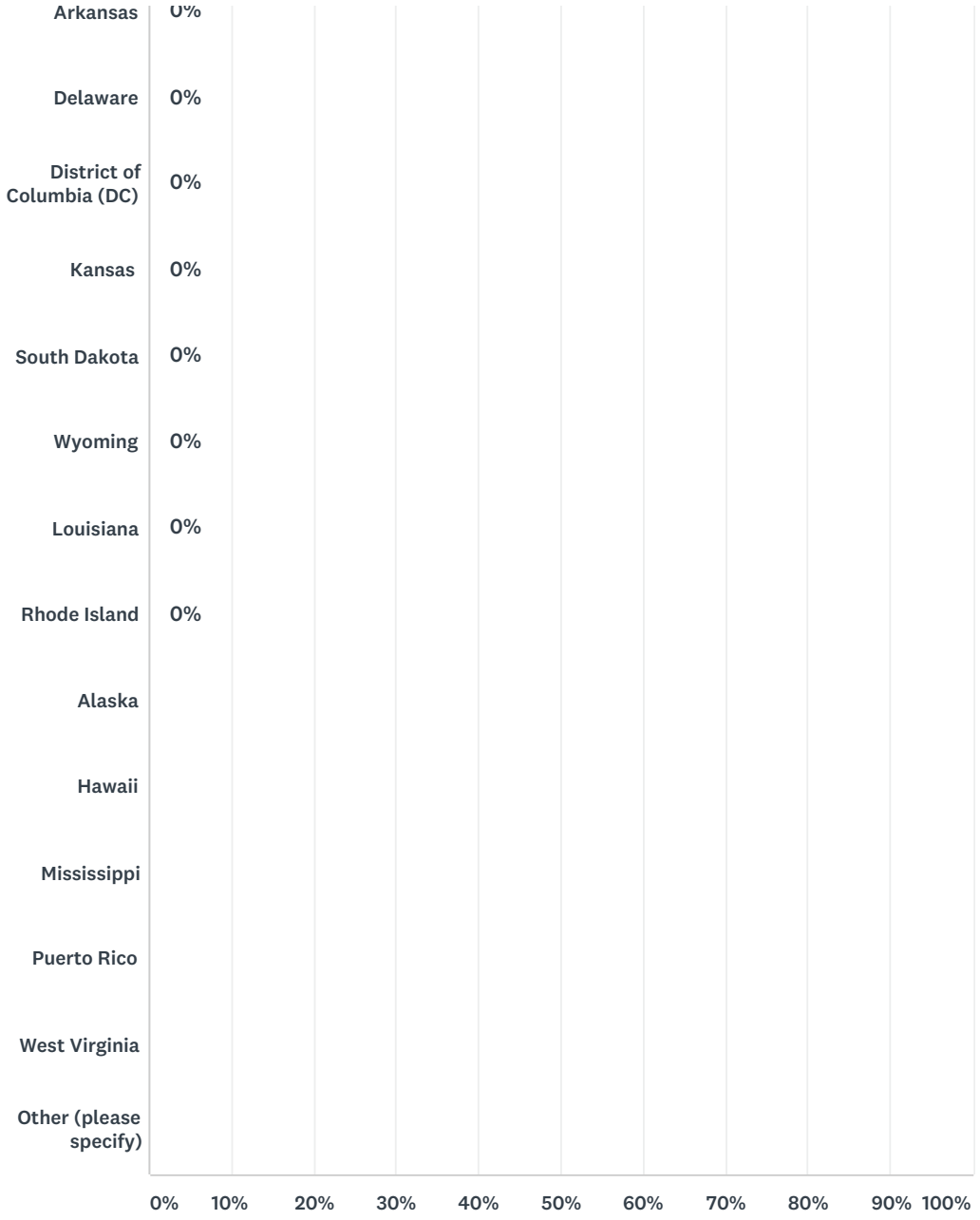
United States	43%	734
Rest of Europe	8%	130
India	7%	116
United Kingdom	6%	104
Germany	5%	83
Canada	5%	81
Eastern Europe or Russia	4%	66
Oceania	4%	62
Scandanavia	3%	58
Latin America	3%	55
Italy	2%	42
Spain	2%	36
Middle East	2%	35
France	2%	31
Rest of Asia	2%	29
Somewhere Else	1%	17
Africa	1%	14
China	0%	5
Japan	0%	1
TOTAL		1,699

Q36 In which part of the United States do you currently reside?

Answered: 733 Skipped: 970




Florida 2%
Virginia 2%
Utah 2%
Iowa 1%
New Jersey 1%
Georgia 1%
Idaho 1%
New Hampshire 1%
Oklahoma 1%
South Carolina 1%
Tennessee 1%
Missouri 1%
Montana 1%
New Mexico 1%
Kentucky 1%
Maine 1%
Nebraska 1%
Nevada 0%
North Dakota 0%
Vermont 0%



ANSWER CHOICES	RESPONSES	
California	19%	137
Texas	6%	44
Pennsylvania	5%	36
Massachusetts	5%	33
Ohio	5%	33
Wisconsin	4%	32
Illinois	4%	30
Washington	4%	30
Minnesota	4%	29

New York	4%	27
Maryland	3%	25
Michigan	3%	25
North Carolina	3%	22
Colorado	3%	21
Indiana	2%	15
Alabama	2%	14
Arizona	2%	14
Oregon	2%	14
Connecticut	2%	12
Florida	2%	12
Virginia	2%	12
Utah	2%	11
Iowa	1%	10
New Jersey	1%	8
Georgia	1%	7
Idaho	1%	6
New Hampshire	1%	6
Oklahoma	1%	6
South Carolina	1%	6
Tennessee	1%	6
Missouri	1%	5
Montana	1%	5
New Mexico	1%	5
Kentucky	1%	4
Maine	1%	4
Nebraska	1%	4
Nevada	0%	3
North Dakota	0%	3
Vermont	0%	3
Arkansas	0%	2
Delaware	0%	2
District of Columbia (DC)	0%	2
Kansas	0%	2
South Dakota	0%	2

Wyoming	0%	2
Louisiana	0%	1
Rhode Island	0%	1
Alaska	0%	0
Hawaii	0%	0
Mississippi	0%	0
Puerto Rico	0%	0
West Virginia	0%	0
Other (please specify)	0%	0
TOTAL		733

#	OTHER (PLEASE SPECIFY)	DATE
	There are no responses.	

Barr Group

2018

Embedded Systems Safety & Security Survey

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