

A HARVARD BUSINESS REVIEW ANALYTIC SERVICES REPORT



**Harvard
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BRIDGING THE GAP IN DIGITAL PRODUCT DESIGN

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SCOTT ROTH
CHIEF EXECUTIVE
OFFICER
JAMA SOFTWARE

Manufacturing companies around the world are looking for new ways to better serve their customers. That often requires them to infuse connected software into everyday physical products. In most cases, businesses understand why they need to build smart products and even know what they want to create. When it comes to how they'll get the work done, however, they struggle.

At Jama Software, we know increasing complexity in product portfolios is difficult for companies to manage, but we believe it's critical for future success. Those that conquer the complex process of developing smart, connected devices will have a competitive advantage in the future—delivering winning products and attracting top talent.

To pinpoint the challenges and opportunities facing organizations embarking on these initiatives, we turned to Harvard Business Review Analytic Services. Their team conducted industry research and compiled expert insights to learn what companies must do to manage the growing complexity of building smart, connected products.

What they found is threefold. First, time-to-market pressure only increases as customer expectations build and competition expands. This pressure necessitates streamlined methodologies for execution.

Additionally, just as the products themselves need to be connected, so do the engineers producing them. Hardware and software engineering teams are converging more than ever before. The challenge is that these groups approach their work in fundamentally different ways. That's why structured collaboration and open lines of communication can help align teams from start to finish.

Finally, companies would be hard-pressed to go it alone. A modern, flexible development environment, like the Jama Software platform and open API, allows engineers to thrive using their preferred approach. The right technology partner can help companies transform their product development process and align to focus on the customer.

Organizations that fail to move on these initiatives risk obsolescence, as they will be outpaced by those investing in advanced development strategies. At Jama Software, we empower forward-thinking companies to realize the powerful potential of the connected world. That starts by building tomorrow's innovative products today.

A handwritten signature in black ink that reads "Scott Roth".

BRIDGING THE GAP IN DIGITAL PRODUCT DESIGN

From smart wristwatches to even smarter washing machines, from jet engines that signal when they need maintenance to jackhammers that detect when their users are tired, physical products in nearly every industry are being digitized with software. As a result, products once unconnected and devoid of software must now be designed to converge the digital with the physical, creating connected smart products and related services.

This need—to infuse intelligence and connectivity into formerly mundane products—is also pushing suppliers to digitally transform their own systems and processes. These companies must keep pace with the growing complexity of their increasingly digitized products.

They're also under increasing pressure to accelerate their time to market with new products and services. Yet many find their product-development methodologies are unsuitable for the accelerated co-development of both hardware and software. Further exacerbating the situation, engineers of physical products and software engineers often struggle to work together effectively.

These are among the findings of a new Harvard Business Review Analytic Services survey of 285 business and IT leaders across a wide range of industries and locations worldwide, all of whom work for organizations that have either begun to digitize physical products or are planning to do so soon. The survey findings indicate that far greater collaboration and communication are needed to bridge the gap between those who design the physical product and those who design the digital features. Not only do the physical and digital features of the product need to converge, but so do the hardware and software cultures.

The convergence of the physical and digital is growing rapidly. “We’ve seen a doubling of activity in digital in the past year. We’ve also seen a lot of anxiety about what to do and where to start,” says Allan Frank, chief digital officer and cofounder of The Hackett Group, a consulting firm, and coauthor of a recent research paper on the digital transformation confidence gap.

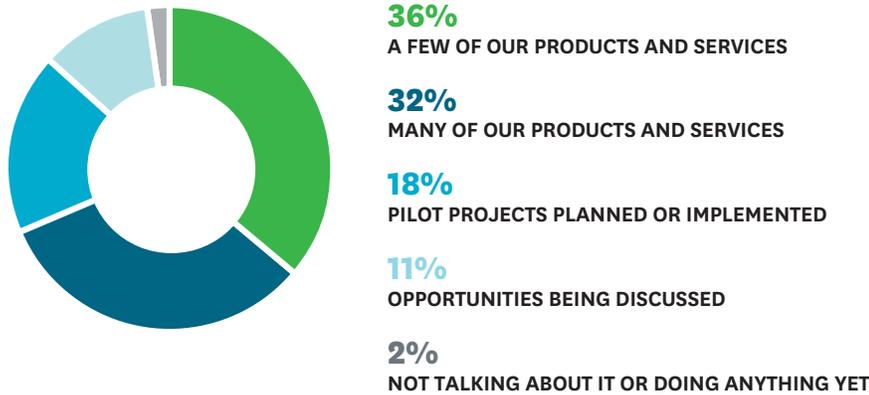
This convergence of software and hardware is already a reality at many organizations. Nearly 90 percent of survey respondents said they’re either implementing digital products now or planning to do so in the future. Only 2 percent are doing nothing to implement digital technologies in physical products. [figure 1](#)

Frank says he expects these figures to rise in the next year or so as more organizations add software and services to their physical products. “There’s a concern that if they don’t do it, someone else will.”

FIGURE 1

DIGITAL TRANSFORMATION: HERE AND NOW

Percentage of respondents stating the category that best describes the extent to which their organizations have applied digital technologies to the product/service development process



NOTE: DOES NOT EQUAL 100% DUE TO ROUNDING

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GETTING FAST FASTER

Time-to-market pressure, already intense in many industries, gets even more intense with the move to digital technologies, say many survey respondents. A large majority (80 percent) said implementing digital technologies has either somewhat or significantly added pressure to increase time to market for products and services. Even more (89 percent) expect that pressure to either significantly or somewhat increase in the future. [figure 2](#)

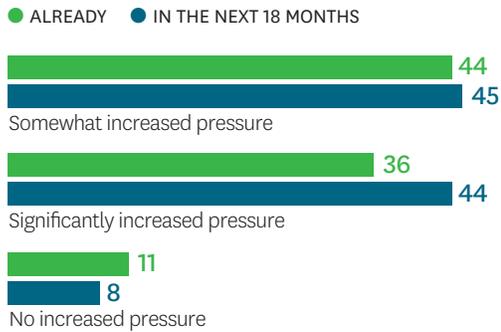
If you think things are moving fast now, better brace yourself. “There will be even more pressure,” says Richard Pastore, senior director of The Hackett Group’s IT research program and lead author of its report. “You don’t reach an acceleration point and stop. Everyone thinks someone will disrupt their market if they don’t go faster. They face pressure, both in front from the customer and from behind by the disruptor.”

Time-to-market pressure demands new, streamlined methodologies. Hardware and most software projects have long used “waterfall methodology,” a sequential process with distinct steps, each of which must be completed before moving to the next. Hardware engineers and many software engineers have been trained to work this way. By contrast, the newer agile methodology is incremental, modular, and iterative. It’s commonly used by developers of web, cloud, and mobile apps who need quick results that can be updated frequently. These developers start small, work fast, develop multiple modules simultaneously, and then build on them in a collaborative effort that produces results not in years but in mere weeks.

FIGURE 2

PRESSED TO MOVE FASTER

Percentage of respondents stating the extent to which implementing digital technologies in the new products and services development process adds time-to-market pressure



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Consultant Frank sees some movement toward a variation of agile for hardware that develops on a shorter schedule, limits the product’s functionality, and uses rapid prototyping. “There’s a body of literature around agile for hardware, and some companies actually do it,” he says. “It is a big change. You need to learn to start small, fail quickly, and iterate.”

Other top challenges of digitizing physical products include planning for diverse ecosystems, aligning traditional design methodologies with the more agile approaches required by digitization, hiring and training qualified staff, and managing and securing customer data. [figure 3](#)

“In my experience working with Global 1000 companies, these are indeed the most difficult problems in designing digitized products,” says Hans Brechbühl, executive director of the Glassmeyer/McNamee Center for Digital Strategies at the Tuck School of Business at Dartmouth. Planning for the ecosystem, he adds, “is a big problem and has given rise to platform thinking. Many companies now provide the platform and APIs (application programming interfaces) that allow environments to interface with whatever is needed in the future.”

Indeed, the days when vendors could develop for a closed ecosystem like the PC architecture are fading, if not gone. “From the perspective of a product developer, particularly the intersection of hardware and software, the ecosystem is one of the biggest issues,” says Frank of the Hackett Group. “Any solution is part of a larger environment and infrastructure.”

Consider just one aspect: communication protocols for internet of things (IoT) sensors have yet to be agreed upon. Frank likens it to the old Betamax versus VHS standards battle from the early days of home video. Now as then, until a standard is picked, developers will be forced to choose one and stay flexible enough to switch if they ultimately have chosen wrong. “When thinking of using a technology, you have to understand where it is on the maturity curve,” Frank says.

FIGURE 3

GOING DIGITAL'S BIGGEST CHALLENGE

Percentage of respondents stating the biggest challenges that their product developers face in the application of digital technologies to the product/service development process

 38

While new smart products must work within a diverse ecosystem of other connected products, planning for those complex interactions is a challenge.

 34

Traditional design methodologies for physical products often conflict with more agile methodologies required for digital transformation.

 24

Hiring and/or training engineering talent for digital transformation are difficult.

 24

With sensors gathering large amounts of customer data, planning to manage and secure this data requires a serious effort.

 20

The methodologies for co-developing physical products that are digitally transformed are still immature.

 18

The tools for co-developing physical products, software, and other digital elements are still immature.

 14

The sensors, software, platforms, and other components for digital transformation change too quickly and unpredictably.

 10

Engineers who work on physical products don't communicate well with software (digital) engineers, and vice versa.

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ECOSYSTEMS AND METHODOLOGIES

So how are managers dealing with these challenges? More than half (52 percent) the respondents say they've partnered with software companies and others to improve their ability to implement digital technologies. More than a third (37 percent) have adopted the new development methodologies. And more than a third (35 percent) have also made acquisitions. [figure 4](#)

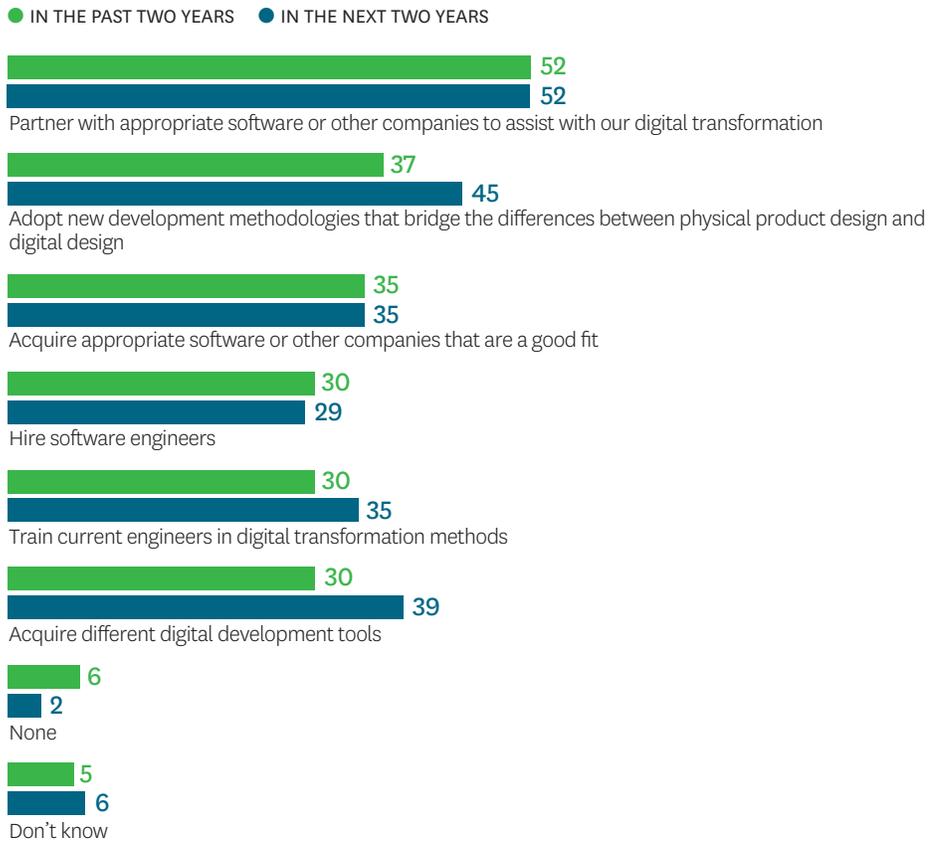
One company that has managed this challenge for years is Nvidia Corp., a developer of graphics cards and high-performance computer chips. "Having hardware and software teams work together is a bridgeable gap for us, because we've been doing it for a long time and our culture binds us together," says Jonathan Sweedler, the company's vice president of hardware engineering. "Without that culture, we'd be in trouble."

Nvidia has managed methodology challenges for years. In fact, the company began co-developing hardware and software long before the process was called digitization. "The transition to hardware and software wasn't a one-shot deal," Sweedler says. "It happened over years as we came to rely more on software. Now I can't imagine what it is like coming at this for a first time."

FIGURE 4

GETTING HELP TO GO DIGITAL

Percentage of respondents undertaking these activities to improve their ability to implement digital technologies in the past two and in the next two years



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One of the first steps Nvidia hardware and software teams jointly take on a project is to agree on the simulator. That’s a software model they use to test all product features, both hardware and software, before going to production. “There is a constant tension between making the simulator fast versus making it more accurate,” Sweedler says. “There is a constant pull between the hardware and software teams, and their goals are not always the same.”

While co-development can be difficult, the more features put in software, the fewer needed in the physical product. For the chips developed by Nvidia, just before manufacturing there’s a design stage called the “tape-out.” It’s a point of no return at which the hardware developers must make their final selection of each feature going into silicon. But the chips’ software developers face no such limit; they can continue to add, subtract, and debug pretty much forever. That’s why, Sweedler says, “We put the simpler features in the hardware—and as many complex features as possible into the software.”

“Who owns the data, and who has the right to do something with it—these are issues to resolve in addition to worrying about securing it.”

HANS BRECHBÜHL, TUCK SCHOOL OF BUSINESS AT DARTMOUTH

DATA AND SECURITY

Brechbühl of Tuck’s Center for Digital Strategies was surprised that fewer than a quarter (24 percent) of respondents cited the need to manage and secure customer data as a major challenge. But he says it could mean that many companies don’t understand how big the issue is. “Who owns the data, and who has the right to do something with it—these are issues to resolve in addition to worrying about securing it,” he says. “If your product or service gathers a lot of data, you’d better be ready to handle it.”

In fact, deciding what data to collect, and for what purpose, should be among the first steps taken to design a digitized physical product. So says Bob Martin, senior principal engineer at MITRE Corporation, a nonprofit organization that operates seven research-and-development centers supporting the U.S. government; he’s also a steering committee member of the Industrial Internet Consortium and an electrical engineer with software experience. “You need to ask, what do you really need in the product?” Martin says. “If you’re taking in gobs of personal information, including the various interactions in the system, then you are putting a liability on everyone interacting with your product and its data and obligating you and them to manage the privacy-relevant parts.”

Martin says the near-indiscriminate collection of data by software—just because it can—can complicate the control testing and assurance needed by engineers of physical products. “The best way to secure something,” he adds, “is to not have it.”

Also, when software has serious problems, vendors can issue bug fixes and upgrades; but when physical products have problems, vendors often face expensive recalls of the actual device. In today’s digital era, it’s just a matter of time before a headline-grabbing recall of a physical product is caused by a software bug in its digitized aspects, Martin predicts. “Data is a central issue that companies must resolve,” he adds. “They need to get hardware and software engineers co-developing digitized physical products that are safe, secure, reliable, resilient, and able to protect privacy.”

HIRING AND TRAINING

All that requires a workforce that is trained and talented. But that’s a major challenge, say more than half (54 percent) of the survey respondents. Sweedler of Nvidia is among them. “Hiring and training hardware and software engineers is my number one problem,” he says.

That’s true even though Nvidia is located in Silicon Valley. There, the company has access to a large pool of hardware and software engineers, a luxury most companies don’t have.

Brechbühl of Tuck’s Center for Digital Strategies has examined organizations that are hiring well, and he says that for these skills they often have to be willing to “go to where the talent is—or where it wants to be.” He cites Bechtel, Volkswagen, Adidas, and Schindler as companies that have opened centers in Silicon Valley, Berlin, or Barcelona, placing them close to top digital talent.

Another approach to the talent search is partnering with a university. While companies have long partnered with engineering schools and offered internships and other support, few have focused on digital skills. “This is new for data science, analytics, and digital programming,” Brechbühl says. “Eastman Chemical, for instance, has done this well.”

In the final analysis, many of the challenges companies face when creating connected smart products stem from the different mindsets of hardware and software engineers. Getting these two types of engineers to work together can be the biggest hurdle of all.

Only slightly above a third (38 percent) of survey respondents said their engineering and digital teams collaborate well together, while nearly as many (32 percent) said they don’t. “There is an inherent dichotomy in how hardware and software engineers see the world—and how the world sees them,” admits Nvidia’s Sweedler. “They have to be different in how they work.”

How to bring these two groups closer together? Pastore of The Hackett Group recommends keeping a keen focus on what really matters—the customer requirements. “Hardware and digital are from two different planets,” he says. “If you’re going to bring these groups together, they have to focus on the customer.”

To be sure, designers of smart, connected products will face big challenges in ecosystems, methodologies, data, and hiring. Their companies must continue to acquire the best available tools to help them through these challenges and continue to fine-tune their methodologies for co-developing hardware and software. And in the end, staying focused on what customers want, need, and expect should be a solid strategy for closing the design gap.

THE FOLLOWING EXPERTS REVIEWED AND DISCUSSED THE SURVEY FINDINGS.

HANS BRECHBÜHL | Executive Director, Glassmeyer/McNamee Center for Digital Strategies, Tuck School of Business at Dartmouth

ALLAN FRANK | Chief Digital Officer and Cofounder, The Hackett Group

BOB MARTIN | Senior Principal Engineer, MITRE Corporation | Steering Committee Member, The Industrial Internet Consortium

RICHARD PASTORE | Senior Director of IT Research, The Hackett Group

JONATHAN SWEEDLER | Vice President of Hardware Engineering, Nvidia Corp.

METHODOLOGY AND INTERVIEW PARTICIPANTS

A total of 285 respondents were drawn from the *Harvard Business Review* audience of readers (magazine/enewsletter readers, customers, HBR.org users).

SIZE OF ORGANIZATION

Forty-three percent were in organizations with 5,000 or more employees; 17 percent were in organizations with 1,500 to 4,999 employees; and 40 percent had 200 to 1,499 employees.

SENIORITY

Seventeen percent of respondents were in executive management or board members; 39 percent were in senior management; 38 percent were in middle management; and 6 percent came from other grades.

KEY INDUSTRY SECTORS

Fourteen percent were in manufacturing; 13 percent were in financial services; 12 percent were in technology; and 10 percent were in health care. Other sectors were each represented by 7 percent or less of the respondent base.

JOB FUNCTION

Twenty-one percent of respondents were in general/executive management; 12 percent were in IT; and 10 percent were in R&D/product development. Other functions were each represented by 7 percent or less of the base.

REGIONS

Forty-three percent of respondents were located in North America; 26 percent were from EMEA; 18 percent were from Asia/Pacific; and 13 percent were from the rest of the world.

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