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World Quality Report

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2019-20 I ELEVENTH EDITION

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World Quality Report 2019-20

Eleventh Edition

Contents

Introduction

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Welcome to the 11th edition of the World Quality Report. In previous editions, we surveyed and analyzed key trends in how enterprises approach software quality. And this year is no exception.

If one thing is clear from this year's survey, it's that the current pace and nature of change in business demand, the adoption of new technologies, and the pace of development methodologies are all accelerating, and that the need for QA orchestration and its impact on enterprises is more radical than ever before.

One of the most impactful changes is the now-widespread adoption of agile and DevOps methodologies by virtually every organization in the world. This change is significant for three main reasons: it enables organizations to let go of old structures and standard rules of operations; it presents the potential to increase delivery velocity to the maximum levels; and it enables working in autonomous feature teams that are empowered to decide their approaches and technologies, and are self-responsible for delivering value and quality with or without a test expert in their midst.

The traditional test skills, such as product risk analysis, test planning, and test management are regarded as outdated because they are seen as slowing down development too much. At the same time, we observe that new skills and technology solutions, such as test automation, data analytics, and AI technologies, are in high demand since they help deliver business value and improved software quality faster.

The new way of working offers numerous advantages. New features are delivered faster to end users. Multi-disciplined teams share a joint objective to deliver customer-focused solutions. Autonomous teams with end-to-end responsibility create an inspirational and dynamic working atmosphere. But the flipside and dilemma for most enterprises is that the fragmentation, combined with a higher velocity of change, also leads to higher risk regarding quality issues, some of which cannot be repaired without a serious impact on customer experience and business performance.

Given the demand for speed and the evolving role of quality assurance, it is more difficult to be sure that teams have validated the correct business scenarios with sufficient coverage. The question to what degree our customer experience is at risk with the next release or feature update is difficult to answer. This also extends to basic operational questions with regards to quality. Why is the test automation level so low? Do we have the right level of enablement for our feature teams to achieve quality? How can we ensure that quality engineering is integrated in the feature team activities?

The World Quality Report 2019–20 offers refreshing clarity on these issues. You will also find engaging insights straight from quality assurance thought leaders on how their teams are dealing with these challenges. I am certain that you will find the commentary insightful and our recommendations actionable.

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As organizations undertake major digital transformations, software-based innovation and development continues to grow at a rapid pace. The demand for IT and Product teams to satisfy the expectation of seamless services for employees, suppliers and customers alike places greater pressure to do more and in less time than ever before. The result is a balancing act to deliver value at high speed without sacrificing quality or security.

Testing and automation remain some of the most critical factors to deliver software reliably and securely, but they also come with costs and complexities that challenge even the most sophisticated teams. Whether an organization is grappling with ensuring adequate test coverage, increasing poor automation rates, or managing a wide range of tooling, one aspect remains clear: testing and automation must be embedded within the end-to-end delivery process.

As this year's World Quality Report shows, progress is being made, but there is still a way to go. While the respondents in the survey agree that end-to-end testing is vital, a lack of testing skills is hampering progress. In addition to traditional skills, teams must acquire new skills such as mathematical techniques, artificial intelligence, test automation, and security. Disparate testing ecosystems also impede comprehensive automated testing, and must be connected in order to define end-to-end business flows.

This 11th edition of the Report offers a number of actionable recommendations to organizations. At the forefront is connecting the diverse testing ecosystem together as a test automation platform, solidifying test data and environment provisioning, and adopting intelligent analytics to make sense of the data across the entire software delivery mechanism. This of course must be backed up by team members with the skills to interpret and analyze the data that the system produces.

When it comes to building and delivering better software faster, you can no longer choose between speed, quality, and security if you expect to remain competitive. Micro Focus' continuous quality and security solutions employ AI and advanced analytics to help you make a cultural shift— offering ongoing and comprehensive testing of web, mobile, and enterprise applications from the start. This is required to quickly bring ideas to life at the pace your industry demands, making users happy and boosting business confidence as a result.

Lastly, I'd like to express my gratitude to our friends and partners at CapGemini and Sogeti, and everyone involved in producing this edition of the World Quality Report.

Executive Summary

World Quality Report 2019-20

This year's World Quality Report shows, once again, that underpinning the key business drivers of every major enterprise – drivers such as business growth, end-user satisfaction, cost control, and security – is the importance of quality, and of the measures that are put in place to maintain it. Many of the trends we identified last year have accelerated their pace, and have been joined by new and equally pressing needs.

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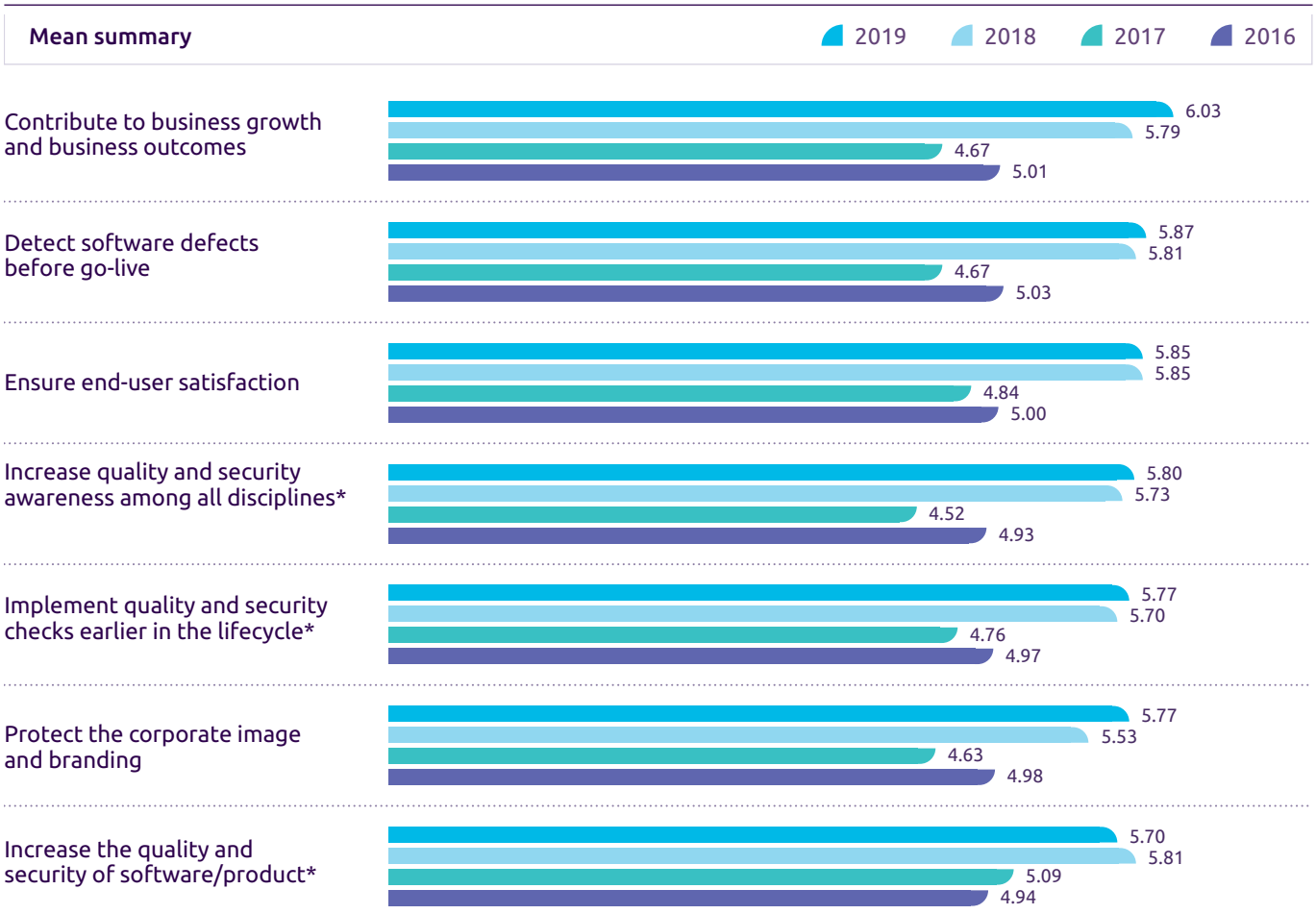
Fig 1 Executive management objectives with QA and testing on a scale of 1-7, where 7 = very important



* Please note, the addition of 'security' in these statements in the 2019 survey

Skills

The question of skills makes a regular appearance in these surveys, and this year's report is no exception. It's a factor in the growth of testing in agile and DevOps environments, in the adoption of artificial intelligence, in the development of test automation, of test environments, and of test data management. Boundaries are blurring between what constitute testing skills and what we consider to be general IT disciplines – and indeed, non-tech areas such as commercial analytics, stats analysis, math, and business expertise are increasingly playing their part.

Security

Security is almost always one of the biggest IT issues in the World Quality Report, and this year is no exception. In the three sub-categories of architecture, policy, and practice, the greatest challenge is in practice: organizations are finding it difficult to ensure their systems are compliant with accepted procedures.

This is no surprise. If technology is a moving target, so, too, are the threats and risks it faces. It's hard for anyone to keep up – which is why here, too, we see that skills are mentioned as a significant consideration. If there were any one field in which lifelong learning is appropriate and necessary, this would be it.

Budgets and costs

Given its importance, it may come as a surprise to some people that the share of IT budget allocated to QA and testing has been falling year-on-year for the last four years. Should this be a cause for concern?

In our view, no. As the 'Report Findings' section of this executive summary explains, we see this not as a sign of lower perceived importance, but as an indicator of

increasing efficiency and cost-effectiveness. There have been developments in the areas covered in the 'Current Trends' sections of this report – Agile and DevOps, test automation, artificial intelligence, cloud-based test environments, and more – and while they aren't all proceeding at the pace we would hope or expect, they are nonetheless streamlining processes and improving outcomes.

Also, development teams are themselves taking increasing responsibility for QA and testing, which adds to the difficulty of tracking separately the real cost of QA.

End-to-end testing

The need to build a smart and connected ecosystem is also occupying the minds of people in many organizations. This will enable QA teams to be ready for the testing of real end-to-end business processes that can cut across various scrum teams and applications. The gap between defining and testing the right dependencies for the complex end to end business flows can be addressed by using this smart and connected ecosystem, while individual scrum teams focus on testing their individual user stories.

QA: an integral part of the picture

It's that gradual integration into the overall development process that is perhaps the most interesting observation we can make this year. We are seeing the beginnings of a fundamental shift in the whole notion of testing and quality assurance (QA) as an entity that is separate from the rest of software development in particular, and of the IT function in general.

If quality loses its discrete identity, will that diminish its relevance? Not in our view. As you will see in this report, it's far better for quality to be implicit in everything an organization does, than for it to be simply a stage in a process.

Key Findings
World Quality Report 2019-20

Agile and DevOps: business drivers are more important than ever

The main strategic challenge QA teams are facing in agile and DevOps adoption is 'operational and business priorities:' now more than ever, teams need to ensure the development projects on which they are embarked are aligned closely to the needs of the business, and also to the customers they serve. This means that new ways of working are required, in the form of a smart, connected, and business-driven ecosystem. This, in turn, means that determining the key performance indicators (KPIs) that define success for agile and DevOps initiatives is crucial.

This blurring of boundaries between development and QA is a major factor in an issue we see, flagged time and again in this year's survey.

The main operational challenge, here in agile and DevOps environments and also, as we shall see, in other contexts, is the issue of skills. Those needed here, in these new disciplines, are significantly different from traditional requirements. The testing and quality assurance industry is undergoing a significant shift, and in order to cope, executives and team leaders are doing all they can to 'rewire' their existing people as well as to hire new talent.

The shift sparked by agile and DevOps is also having an influence on when testing and QA happen in the lifecycle. It's no longer necessarily a closing phase, but something that can happen in parallel with development. We can expect to see an increase in the introduction of intelligent, connected ecosystems that are flexible, self-sustaining, and that keep pace with need. Here, too, skills are needed to maintain the momentum of change.

This blurring of boundaries between development and QA is a major factor in an issue we see flagged time and again in this year's survey, among respondents as a whole, as well as in individual geographies and sectors – and that issue is the need for full lifecycle testing. It is very important not to lose focus on validating the end-to-end business process, connecting individual capabilities and product groups. When ecosystems are finally connected, there will be scope for seamless QA, bringing an end to the siloes we currently still see. Organizations are not yet tackling this methodically. We recommend serious attention to be given to end-to-end testing, to truly provide business assurance, as organizations scale to enterprise agility.

Artificial Intelligence: broader skills needed in QA

Organizations are exploring artificial intelligence (AI) in QA and testing in a number of ways. Artificial intelligence can make testing smarter. It can conduct real-time risk assessments; it can find the issues that need to be addressed; it can prioritize them; and it can optimize an approach to create testing that is both predictable and fit for purpose.

Artificial intelligence can, in short, help testing teams make the transformation to smart testing – to do things right (efficient), and also to do the right thing (effective).

As with agile and DevOps, implicit in AI developments is a range of skills issues. It's not just about the need to understand and create appropriate algorithms; it's also about aligning testing and QA more closely than ever before to the needs of the enterprise by making non-technical knowledge a fundamental part of the process. Statistical skills, mathematical skills, metrics that are specific to the business's strategy and ambitions – all these will need to form part of the AI-related armory for QA and testing.

Indeed, in last year's report we said, "The use of AI in testing is also likely to require newer skills and create newer roles such as AI QA strategists, data scientists, and AI test experts in QA and testing teams." That need is still with us and, if anything, the momentum is building.

As part of our survey, we asked participating organizations to tell us of the AI and machine learning projects they have in place, and significant numbers of respondents have told us they are active in both areas. While machine learning projects in general may indeed be under way, we at Capgemini don't see many signs of this approach being applied specifically in testing. In our view, organizations aren't yet mature enough to take advantage of it.

In AI, however, we do see signs of early activity. It's a clear bid to achieve those new levels of efficiency and effectiveness we just mentioned – and in fact, we anticipate some beneficial convergence with machine learning. As organizations grow accustomed to machine learning, they will increasingly understand its distinction from artificial intelligence. They will see that in order for AI testing to be effective, it needs access to the right data – and machine learning can provide this, by processing records in volume, thereby helping to identify and optimize test cases. When this stage has been reached, we can truly say smart testing has arrived.

Perhaps the most surprising thing about test data and test environments management (TDM and TEM) in this year's report is how little progress is being made.

Test automation: teams need a smart, common, end-to-end environment

Earlier in this summary, we noted how frequently this year's respondents have referred to the need to automate from end to end – from build through to deployment. It's an indication of how the topic of test automation has moved on. It's no longer regarded as functional, but as a full-lifecycle need. This is partly because of the increasing adoption of DevOps: it's only in the context of the applications development cycle as a whole that full benefits can be realized.

As part of this, we're seeing the emergence of model-based testing (MBT) – the design of automated test cases, taking automation beyond its traditional scope.

That said, many organizations have not been able to get the level of return of investment from automation initiatives they would have wished. This is because most frameworks lack the cognition they need to self-heal. They are designed to automate manual steps, but they are not sufficiently intelligent. In other words, they can't react to changes, dynamically generate the resources they need, or understand and interpret results.

This has led to significant maintenance effort, particularly at a time when apps are developing at a pace that makes it hard for QA and test teams to keep up. The result has been the adoption of a multiplicity of automation tools, which is understandable, but which doesn't always necessarily help. If, however, these tools were connected, and were held within a smart framework, many of the issues would resolve themselves. Test cases would be able to talk to one another, find the data they need, and fix or fine-tune themselves.

We've also seen significant growth in the use of Open Source automation tools, at the expense of some commercial products. It's partly about cost, of course, but's also about flexibility, and about solving problems collegiately within the Open Source community.

The multiplicity of tools in circulation would, in our view, be less of an issue if people approached test automation with a different mindset. Instead of thinking of it as a capability, they should think of it as a platform – as a broad, connected, and smart space. When it ceases to be a matter of integrated individual tools and of bringing together their respective functionalities, and becomes instead a common environment, that's when broader, business-driven benefits can be given the priority they deserve.

TDM and TEM: insufficient progress

Perhaps the most surprising thing about test data and test environments management (TDM and TEM) in this year's report is how little progress is being made. Surprising, yes – and also disappointing. For instance, our survey shows that 20% of respondents' testing is said to occur in cloud-based temporary test environments, while considerably more – 30% – takes place in a traditional, permanent test environment. We also see little change in cloud-based testing as far as the functional testing of business intelligence and business analytics solutions are concerned. What's more, there is little movement in the functional testing of core enterprise packages, such as the major CRM, ERP and financial system platforms.

Why this inertia? We suspect three factors are at work here. The first is the comfort of the known quantity: people feel safe with the status quo, which means that – currently, at least – they are prepared to forego the benefits that change might bring. This is particularly surprising when we note that 60% of respondents this year say that the greatest test environment challenge they face is cost. This figure is up from 39% just two years ago. When cloud-based environments and the scalability they offer can do much to address the issue of cost, one would think they would prove more attractive than seems to be the case at present.

The second possible reason for lack of progress may be people's attitudes to corporate data. This year's figures seem to suggest there is less appreciation of its value than might be expected. While the drive for digital transformation is widely recognized, the role that data has in driving the business doesn't seem to be fully understood by testing and QA teams.

The third and final reason is by no means the least important. It's simply the pace and size of change. When business pressures lead to multiple developments, each with frequent changes; and when data cuts across siloed systems, making it difficult to sustain a comprehensive and enterprise-wide view – in these fast-moving and disparate circumstances, it's difficult to stand back sufficiently and chart a course.

But this, of course, is precisely what needs to happen. The status quo is falsely attractive, and greater boldness in the adoption of new approaches to test environments and test data can significantly address workloads issues, improve quality, and help to manage costs. There are some signs that things are beginning to change – but we may need to wait until next year to gauge whether there is any real momentum.

The share of IT budgets allocated to quality assurance and testing has dropped to 23%

Security and risk compliance: still the most important part of IT strategy

Security and risk issues were given greater prominence in this year's World Quality Report. It's an area of great concern: almost every year, including this year, it's deemed by our survey respondents to be the most important aspect of their overall IT strategy.

In a new question, we asked about the challenges organizations experience in securing their applications data. The responses fell into three broad categories: issues with the architecture of data security; issues with the principles and policies surrounding it; and issues with security practice. It is this last area that our respondents consider to be their greatest challenge: 59% of them report deficiencies in the controls they have in place which ensure that the systems that consume, process and store their data adhere to embedded security policies.

As in several other areas of quality assurance (QA) and testing, so here: behind this difficulty with security practice lies the question of skills. In a fast-changing environment, testing teams need to ensure they are equipped to deal with anything, even if that means looking for external support.

This year, we're also seeing the effects on security of general developments in QA and testing. Security testing being performed in cloud environments has risen to 58% from 42% in 2015 and, as our main security section notes, we expect to see that figure rise significantly higher. Agile and DevOps have also had an effect. When asked to what extent agile and DevOps have changed the skills expected of QA and test professionals, more than one in four respondents (27%) said security skills are lacking. So, too, has automation: more than half our respondents (53%) believe it is reducing their overall security risk.

Of course, one of the most important findings in this field is one of the most abiding. It's the fact that secure development, quality assurance and testing will always be work in progress, because risks will continue to evolve, and so will the regulatory environments that help to safeguard against them. Abiding by those regulations, and keeping ahead of the threats, are a necessary part of corporate existence – and testing and QA have a significant role to play.

Cost containment and efficiency: testing and QA budget share is down – but this may be because QA is becoming part of the mainstream

In 2015, respondents to the World Quality Report survey said that more than a third (35%) of their overall IT budget was allocated to the testing and QA function. Since then, the trend has been downwards, and this year, the figure stands at just 23%.

We see a number of factors at work here:

- The growth of cloud computing has influenced how enterprises structure themselves and has increased their efficiency
- Virtualization is having a similar effect
- The increasing adoption of agile and DevOps approaches has enabled QA to become more integral to development processes, thereby shortening time-to-market and improving cost-effectiveness. That said, the question of whether the budgets for testing are really being tracked properly remains unresolved
- This increasing integration of testing and development also enables organizations to locate and address defects earlier, and implement updates sooner
- Test automation helps with prioritization and increases throughput volume

On this last point, however, our survey this year shows that automation for testing purposes is not growing as fast as might be anticipated. This is a shame, because smart automation, in particular, is set to make a significant difference: it can find and fix issues quickly, and help combined test-and-development teams decide which changes will deliver the best and fastest returns. We expect to see substantial growth here.

The general trend we're seeing in cost and efficiency terms, and to which we have already alluded, is that quality issues are ceasing to be regarded as a discrete area of activity. Competitive demands and digital transformation are increasing the momentum for more apps and more functionality in shorter delivery times, and as a result, it's highly likely that testing and QA will be subsumed end-to-end in the development process.

This won't just be cost-effective: it will also be the philosophically right thing to do. Because quality is not, and should not be, any kind of bolt-on. It should be integral to everything an organization aims to do and be.

Our Recommendations

Build a smart and connected testing ecosystem deploying intelligent analytics

General trends we're seeing in quality assurance (QA) this year include: an increasingly business-driven approach; a rise in demand for end-to-end testing; and a growth of interest in artificial intelligence (AI).

We believe that one of the best ways to meet the needs implicit in all these trends is to create an intelligent, integrated, and holistic approach to testing. By definition, a connected testing ecosystem can provide continuous monitoring and delivery of system developments, right across the production cycle.

If that ecosystem is also smart, it can harness intelligent analytics to detect issues in real time, and simultaneously generate test data automatically. It can also feature test scripts that are intelligent and adaptive, responding to real-world use patterns.

None of this new-found functionality can be allowed to work in a vacuum. The smart and comprehensive ecosystem needs to be fit for purpose – and that means it must be attuned to the factors that define success for individual organizations.

Expand AI-related skillsets within the test team by onboarding data science, statistics, mathematics, and more

In previous editions of this report, we have pointed out that AI is likely to make new demands of testing and QA teams. This year's survey shows that people are as acutely aware as ever of the need to extend the skills to which these teams have access. As such, our recommendation to focus on this requirement is already very clear to the many organizations from which our respondents are drawn.

Core domain skills must of course be maintained, but they must be complemented by new strengths in automation, in test environments and test data, and by software development engineering testing (S-DET).

Also, the broader, business-driven mindset that is now achieving dominance means that softer skills are required, including the ability to understand and collaborate with the mainstream business, so as to ensure that testing and QA will deliver outcomes that are as appropriate as they are high in quality.

But even that is not all. The growth of AI in business is creating a twin requirement: first, the need to harness smart developments for strategic and tactical business advantage; and second, the need to use AI specifically within testing and QA. If an organization seeks to ensure AI will deliver in both these ways, it needs to attract, retain and develop the requisite knowledge. This includes skills in data science, in statistical analysis, in pure and applied mathematics, and in the understanding of cognitive processes. Many of these are currently outside the remit of the typical testing and QA team, but in our view, they are set to become part of the norm.

Raise awareness and visibility of test environments

The onboarding of new skillsets that we have just recommended includes the need to increase skills specifically in test environments (see above). But it's not just about raising skills levels. Organizations first need to create a greater awareness of the issues that surround these data environments. These include the mappings, integration points and configurations that will make them fit for purpose.

It's the lack of progress in these areas that seem to have resulted in the slow adoption not just of cloud-based test environments, but also of virtualized, containerized, and temporary-but-non-cloud-based test environments. Raising awareness of configuration and integration matters will help determine not just virtualization strategies, but environment contentions, issues with availability, and incorrect configurations.

Progress in data environments seems to have been hampered by cost concerns. We recommend that organizations put more emphasis on a cloud-based approach, which could do much to address this issue. What's more, a cloud-based approach also increases visibility into whether test environments are available, which makes coordination and management easier, and which also, and perhaps significantly, increases cost-efficiency.

We also recommend that awareness of test environments is raised in the broader organization, beyond the world of testing and QA. The more teams can communicate the long-term business benefits of smart test environments and test data, the greater the chance of corporate buy-in, and the lower the likelihood of cost concerns.

Adopt a center of excellence approach for test data management

The pace of change in business is unrelenting, and the arena of test data management is no different. By creating a center of excellence dedicated to this area, organizations can create and maintain real-time test data from production systems, ensure its consistency, and deliver it on an as-a-service basis to the scrum teams that need it.

In a world in which software releases rapidly replace one another, in which market developments create new requirements, and in which systems and platforms vary and multiply – sometimes sharing data – a center of excellence can be a crucial addition to the testing and QA function, and by extension to the organization as a whole.

Re-imagine test automation as a platform

This year's survey data, and our own observations of global business, both tell us that test automation is growing in popularity, and that the rate of adoption is quickening. We've already noted in this executive summary that we expect to see the pace accelerate further, particularly as smart technologies become better established.

But right now, test automation is not delivering the returns expected of it. This is partly because those smart technologies haven't yet delivered the intelligent analysis or the real-time reactivity that will deliver a step-change in performance – but it's also because automation is still so disparate, with a multiplicity of tools that, individually and collectively, are not meeting organizations' challenges.

We recommend a change of thinking about test automation. Organizations should regard it less as a capability, and more as a platform. It should be seen as a broad arena shared by tools and functions that come together to fulfil a collective purpose, working intelligently from end to end – and driven by the objectives of the business.

It's a given that technology moves fast, and that threats to security are growing as a result – but it's also the case that external expectations are rising, not just among regulatory bodies, but among customers, too. In the face of a demand that is growing not just in size but in complexity, it's incumbent on organizations to ensure their security procedures keep pace. The QA and testing function plays a significant part in sharing this burden.

Security, and security testing, be factored in at the earliest stages of the design lifecycle

To raise the game on security, we recommend that QA and test teams increase their introduction of automation in this area. It means more tests can be conducted, and faster – and our survey results show it's also felt by many to reduce risk.

For similar reasons, we also recommend that more security testing be moved to cloud-based test environments. It's an approach that is fast, flexible, and iterative.

A further recommendation is that security, and security testing, be factored in at the earliest stages of the design lifecycle. It's part and parcel of seeing security as an integral part of development – but we imagine few, if any, organizations these days need telling this.

Nor do they need to be told that this is a field that demands continued vigilance. Threats and risks will never be removed altogether – but they can be mitigated, and it's the duty of every organization both to demonstrate and to practice its full commitment.

Current Trends in Quality Assurance & Testing

Orchestrating quality assurance in agile and DevOps

Enterprise agility needs new ways of working – and new skills

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One of the key questions in our survey this year, which we included for the first time, was to ask about the main challenges teams are facing in agile and DevOps adoption.

Unsurprisingly, perhaps, the most popular option was "operational and business priorities." Here, and pretty much everywhere in discussions of enterprise-level systems, it is accepted that technology is being aligned ever more closely to the needs of the business, and, by extension, to the needs of the customers the organization serves. (Indeed, it's difficult now to recall a time when systems were somehow run at arms' length, driven largely by their own technological circumstances and requirements.) In our own experience, determining business KPIs that define success for agile initiatives is key, and aligning on priorities based on business outcomes is what drives the execution strategy.

The next most popular options were the technology stack and the organizational skill set. The technology stack is related to the plethora of legacy, vendor-managed and digital systems talking to each other, hence increasing complexity.

The pattern is clear: how can I find the right technology solution and develop the right talent to ensure achievement of business objectives?

What might also cause no surprise is that only 1% of respondents saw no challenges at all. Practically everyone knows that here, as in other areas of life, something that is still evolving requires application and effort in order to deliver benefit.

We have seen agile and DevOps adoption accelerate in recent years. Indeed, last year, 99% of respondents said these ways of working were being used in some manner. But it's important to remember first, that they are not alternative methodologies; and second, that they are not necessarily discrete. For instance, DevOps approaches may typically be conducted in an agile context, but they could also form part of traditional Waterfall developments.

The acceleration in this adoption has fundamentally transformed how testing is done. In earlier years, it was something that happened at the end of the cycle. But now, testing increasingly takes place in parallel with development, and is engineered for quality.

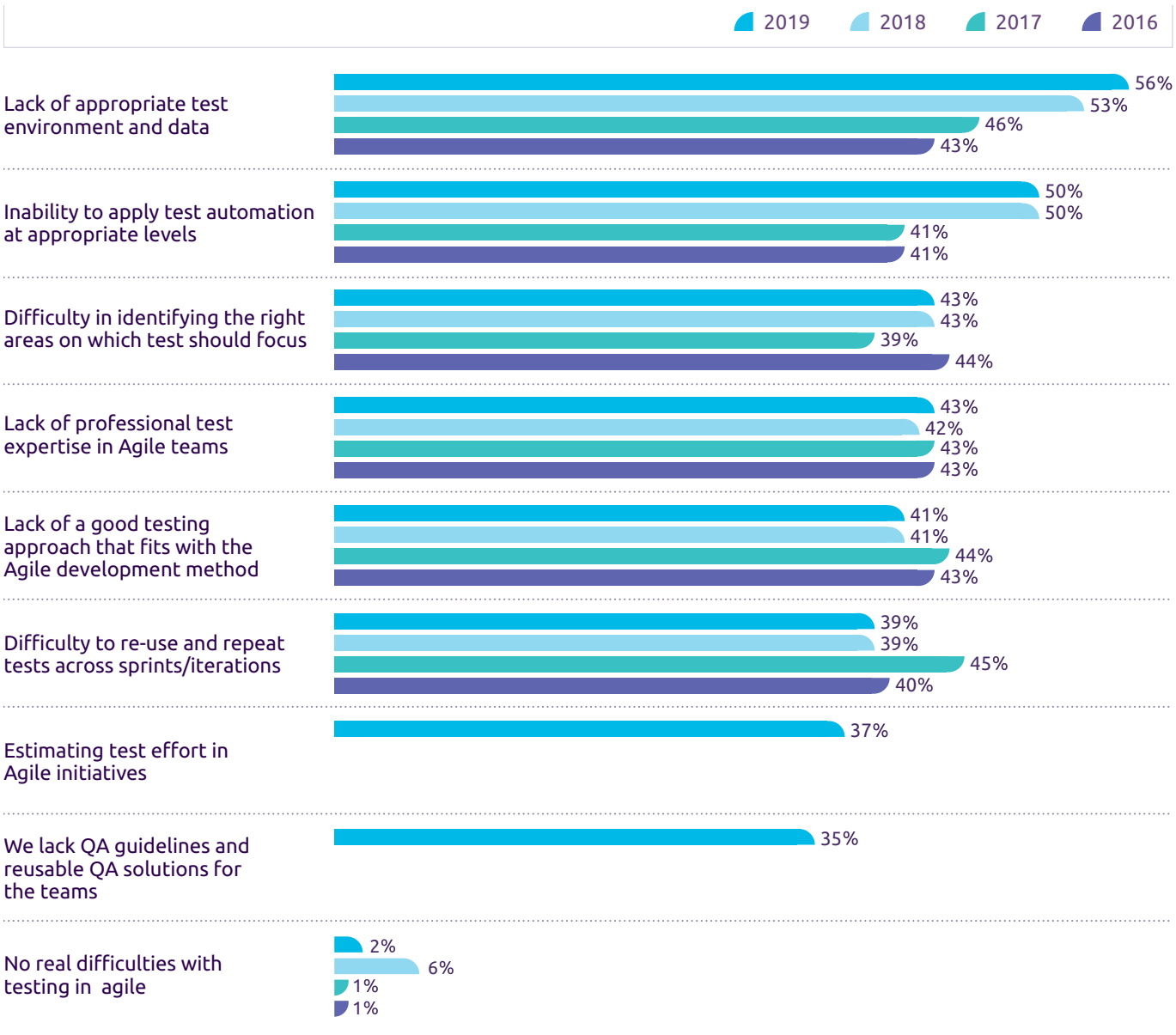
New approaches

New ways of automation mean that testing is not dependent on the availability of stable applications, and can happen in parallel with development. The implications for this are wide-ranging, not just in terms of outcomes and process flows, but also in terms of how we use agile as the delivery norm, designing intelligent connected ecosystems that talk to each other, learn from each other, are adaptive to change, are self-sustaining, and never fail the key need of the hour.

Some of the key technical features of this connected ecosystem are as follows:

- Intelligent adaptive test scripts that respond to changes in UI
- Real-time test data generation from production
- Automated code resiliency: if a release candidate fails, the code base can be rolled back to the previous version
- Continuous monitoring: uninterrupted validation and health check of services in production to detect issues in real time
- Continuous delivery with automated planning build, code, tests, and monitoring integrated in assembly pipeline with 100% system availability.

Fig 2 Challenges currently faced in applying testing to agile developments



Challenges

Agile may be a development methodology of choice, but organizations still have challenges to overcome (See Fig 2). The lack of appropriate test environments and data is a particular impediment. Script automation may well be growing in practice, but increasing levels of system integration make it a difficult proposition. At enterprise level, agile initiatives each have their own criteria for test environments and test data, and accommodating them all exacerbates the problem. A great deal of effort is going into developing appropriate solutions, but there is still much to be done.

This year, for the first time in the context of "challenges for agile development," we suggested this option: "We lack QA guidelines and reusable QA solutions for the teams." As the graph shows, more than a third of our respondents concurred. In orchestrating efforts, defining lightweight test methods and guidelines will, we believe, be of great importance to the enterprise.

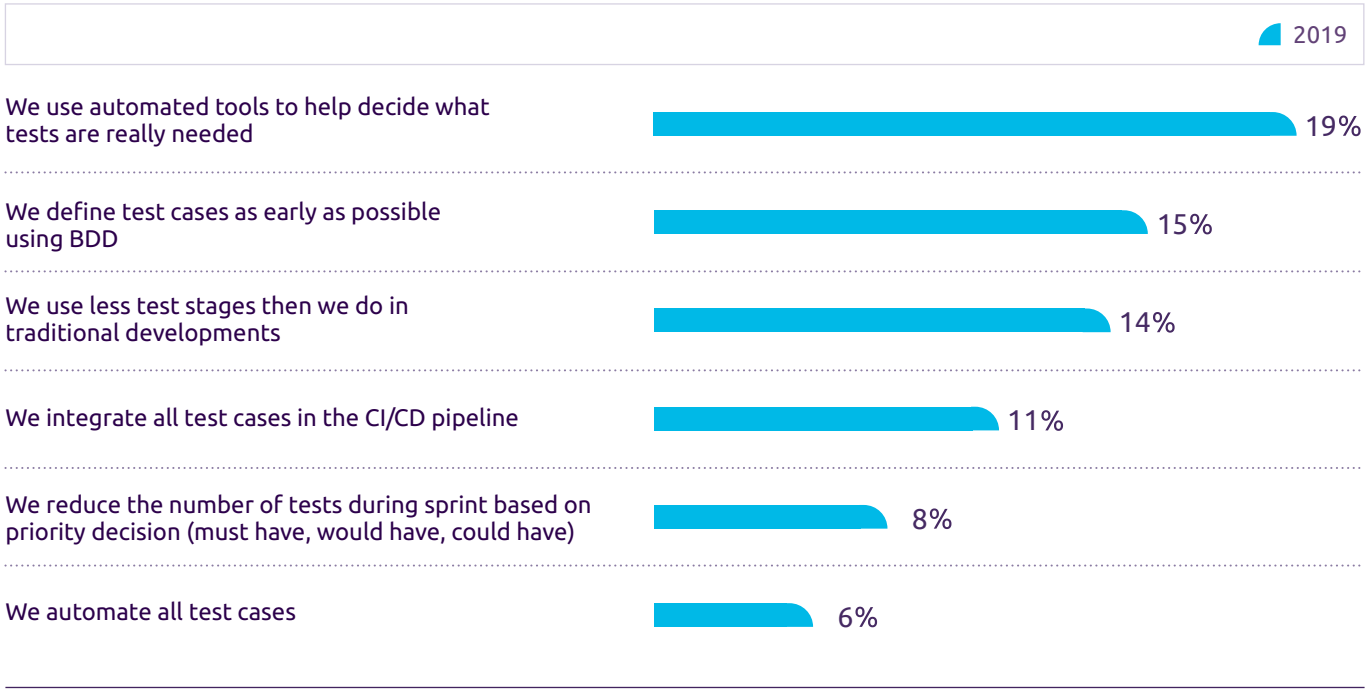
One of the key challenges organizations face with the agile model is the end-to-end testing of business processes. Individual scrum teams are focused on testing their user stories, and this leaves a gap in testing for real end-to-end business processes that cuts across various scrum teams and applications.

Intelligently prioritizing testing need

Decades of technological evolution have shown that when a new development arrives on the scene, the temptation is strong to apply it wholesale, and in all contexts. That has also been the case with testing approaches, and this year's survey (See Fig 3) shows that many enterprises are resisting that temptation. In our experience, they are using smart analytics to determine what to test, as well as model-based testing to accelerate automation and reduce maintenance effort of test scripts. Generally, it is no longer a question of testing everything, but rather intelligently determining what to test.

Here, too, the question was being asked for the first time. We can anticipate growth in this trend when we return to this question in years to come. However, we must add a note of caution. The figure of 19% is not borne out by our own experience, and we suspect it reflects optimism for this judicious approach, rather than reality. We have no such doubts about the stated use of behavior-driven development (BDD).

Fig 3 Likely use of specific approaches to speed up and optimize testing in agile and DevOps developments



Workforce transformation

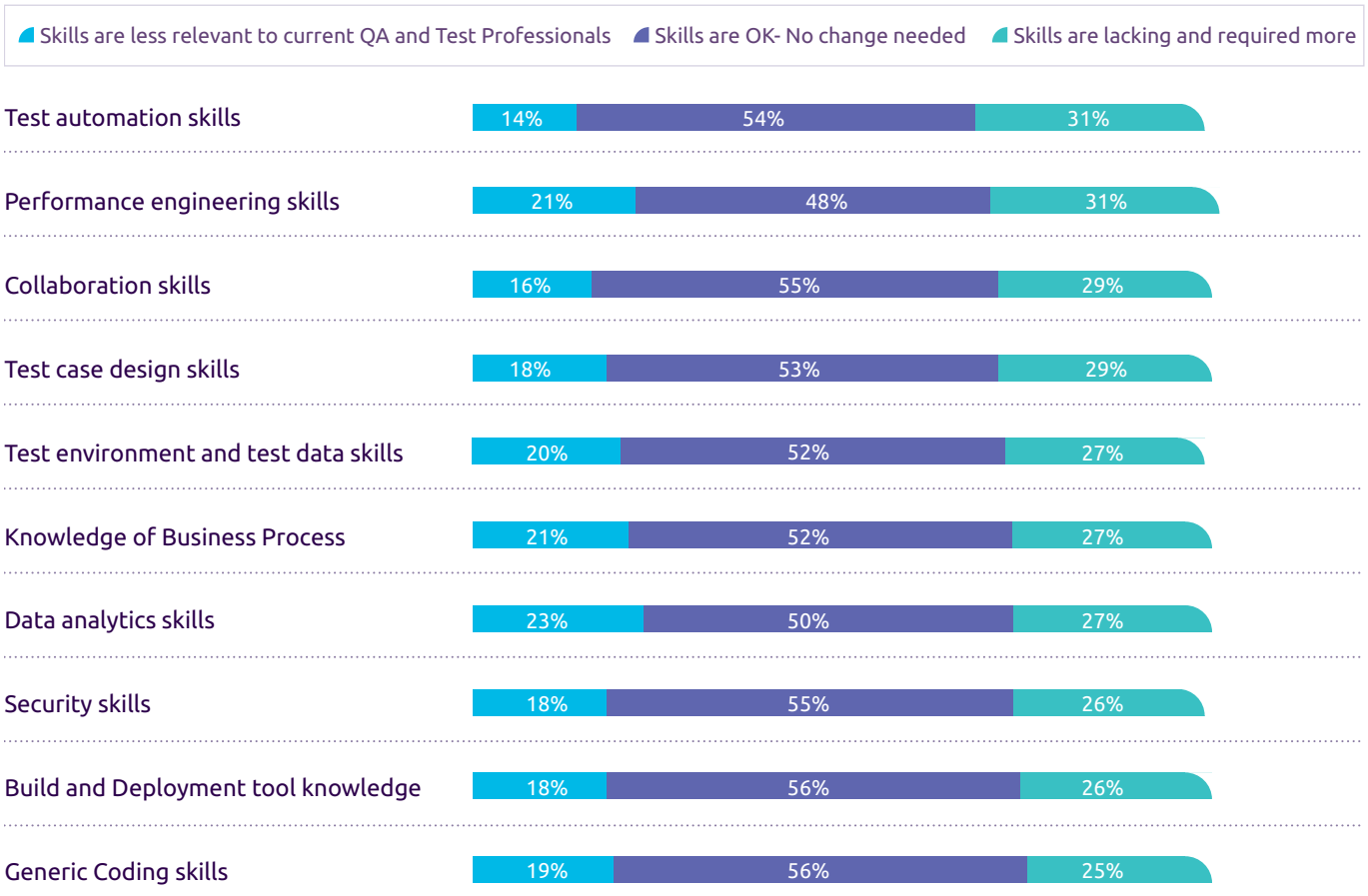
To what extent do agile and DevOps change the skills our respondents need from QA and test professionals? The answer is: a great deal. It is, indeed, a key need of the hour. Across the board, in every area of testing (See Fig 4), around 30% felt skills were lacking. Organizations continue to find it a challenge to find full-stack testers. How are they to build the right skills pyramid?

This is partly because the complexity of skills needed in agile development is increasing. What started several years ago as an automation proposition has since been compounded by issues relating to environment and data, by software development engineering testing, and by new skills, such as the ability to build and deploy, and also to collaborate. Also, and as we have seen in this article, it's very important to continue to retain domain skills, in order truly to act as the liaison between IT and business.

Summary

In summary, as organizations scale to enterprise agility, intelligent ecosystems that derive appropriate test requirements, lightweight test methods, and an automated mechanism to integrate tests in the continuous delivery pipeline, are all a must. Above all, a skilled workforce, and the ability to train and retain that workforce, are critical. It is not just change, but the ability to thrive and survive with change, that demands innovation in designing agile connected ecosystems.

Fig 4 The extent to which agile and DevOps adoption changes the skills expected of QA and testing professionals



LeaderSpeak:

Notes from quality assurance thought leaders

Werner Soeteman
Manager Service Center TEST
Air France KLM

When our survey this year asked about the main challenges organizations faced in agile and DevOps adoption, the most frequent response we received was 'operational and business priorities.'

That's certainly the case for a busy airline group like Air France KLM. In recent years, it's been undertaking a move to these new development methodologies, while at the same time ensuring that commercial needs continue to be met.

The move began five or six years ago in the e-commerce domain, with a shift from Waterfall to a fully agile way of working. This transition has been a success.

Moving to agile

"Over the last three years," explains Werner Soeteman, Manager Service Center TEST, Air France KLM, "our unit costs have been under pressure, and of course as an airline group, we are also driven by the markets, by the general pace of developments, and by cost and efficiency considerations. After our success in e-commerce, this has led us to consider moving IT delivery for the entire organization across to an agile approach. It's been a huge challenge, because some departments are more flexible than others in relation to the idea of change."

"We think we've found the best framework to fit our needs," Werner says. "We chose the SAFe ™ methodology, and for two main reasons. First, it was the least disruptive: it enabled us to keep our current rules on functions and change. Second, it provides the best solution at enterprise scale, which is of course what we needed. Also, areas such as continuity and corrective maintenance all fit within it."

A new model for testing and QA

The organization currently has around 400 product teams, at different levels of maturity – and the demands these different levels make can be quite varied, which is why the company's approach is so interesting.

"When we started with the full implementation after the e-commerce pilot," says Werner, "the testing in the teams was done by the developers themselves. With this principle established, we created a service center, delivering services to teams when specialist knowledge was needed that was beyond the scope of the operational team."

"We then realized," he continues, "that what was also needed was not just support for teams, but orchestration between the teams. In any one flow, comprising multiple feature teams or product teams, we needed to ensure that things were kept in synch. That is now the biggest challenge for us. Within individual teams, there are few issues: people know what to do, and they know how to use the tools, but it's the overall flow that needs to be coordinated."

That's why, Werner explains, the QA function doesn't do the actual testing any more. "We do everything around it, though," he says, "including providing test automation frameworks, helping with test environments and test data, suggesting test strategies, and maintaining overall governance. The goal is that the development team do the actual test execution and analysis themselves. As a result, we ourselves can now perhaps be seen not as a service center for testing, but as a center of excellence and enablement. We're not there to do the testing; we're there to help others do it for themselves."

Werner has two major concerns. The first is that, in an agile and SAFe context, the responsibility for quality has been moved from the IT function to the product owners. These owners are largely drawn from the business, and they are, as you'd expect, more interested in functionality than they are in building quality elements in both functional and non-functional areas, such as performance and security. This can grow over time to become an issue, which is why the organization has had to consider re-assigning responsibility for the technical quality aspects to the IT teams.

The second concern is end-to-end testing. Teams are working in siloes, so there are integration issues. "We are trying to solve this by orchestration," Werner says, "so we have a dedicated test environment management team, who monitor version consistency and technical availability, and who provide all the rules and guidelines – but this is still an area in which we need to gain momentum."

Broadening the scope

In the past, individual teams sometimes developed their own, separate approaches to test automation. This wasn't especially useful. It's an area that's best centralized, leaving those teams to focus on test execution. "That said," says Werner, "as a central enabler, we're not above taking great work that's been done in the field, and that works in the context for which it was designed, and then industrializing it for use elsewhere in the organization."

"It's not just about agile," Werner explains. "We're also looking at DevOps – because if you want continuous testing, that's what you need. It provides a pipeline for development and testing. It's still early days for us, but we're serious about it. Our aim is to give access to this pipeline to people who have test responsibilities within their teams, but only if they can demonstrate they have the requisite skills."

Test automation is a challenge, too. "There are so many tools and approaches," Werner says. "We have set up a pipeline, and we're making it available to as many teams as possible."

The many teams in place at Air France KLM mean that when it comes to support, the organization has a wide variety of circumstances to consider. It needs flexibility in areas of technology including security, blockchain, and artificial intelligence, and it needs to be able to scale up and down quite fast in terms of headcount and knowledge. External knowledge is brought in when and where it is needed – for instance, in security testing – and the organization has identified the areas in which it wants to grow its in-house capabilities, including test automation and test environments.

What does the future hold? A lot, says Werner. "As we continue our transition to agile and DevOps, we're going to keep developing our center of excellence supervision and regulatory model. This continuing evolution will enable teams to conduct their own quality assurance across their complete development cycles. It's a radical change. We're no longer QA service providers. Instead, we're giving agency to the people who need it."

We chose the SAFe™ methodology for two main reasons. First, it was the least disruptive: it enabled us to keep our current rules on functions and change. Second, it provides the best solution at enterprise scale, which is of course what we needed.

Artificial intelligence and machine learning in quality assurance

Artificial intelligence (AI) and machine learning (ML) in testing need to focus on efficiency and effectiveness

Shiva Agolla
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Chessler Matthew
Account Executive-Delivery Capgemini

With increases in digital footprints and cloud adoption, one of the greatest challenges businesses face is how to make the best of technological advances. Other significant factors are the business risk from both legacy technologies, the approach being taken to build and maintain their IT assets, and the need to sustain the customer experience. All of this directly drives the sheer volume of tests with which organizations have to deal to meet their business outcomes. These tests can run into the thousands – and that's why deciding what to test, when, and how much, occupies so much of their time and attention.

At the same time, the ground continues to shift between them: releases are fast-paced; requirements change frequently; operating environments can multiply; and with everything in a state of flux, the result is high numbers of test cases, with many iterations. For example, an enterprise-wide SaaS implementation or an e-commerce app may be under development that will ultimately be rolled out across several platforms. Each will need its own test, and every change or addition to the SaaS/app will need to be replicated and tested across them all.

Organizations must decide how, if at all, they can optimize the execution of so great a workload – how they can process all the data, and feed it back into development and implementation as hard knowledge, and not merely as guesstimates. This may well involve using machine learning to sift and collate data in volume, so as to create test data on which AI testing systems can act. In this context, machine learning is a subset of artificial intelligence.

In short, artificial intelligence can make testing smarter. It can conduct real-time risk assessments; it can identify and prioritize issues for actioning; and it can optimize an approach to create testing that is both efficient and effective. It's about doing things right – and it's also about doing the right thing. The smart result for that e-commerce app might be just one test script, adapting itself intelligently to each platform scenario, and increasing its resilience at the same time.

Maturity is coming

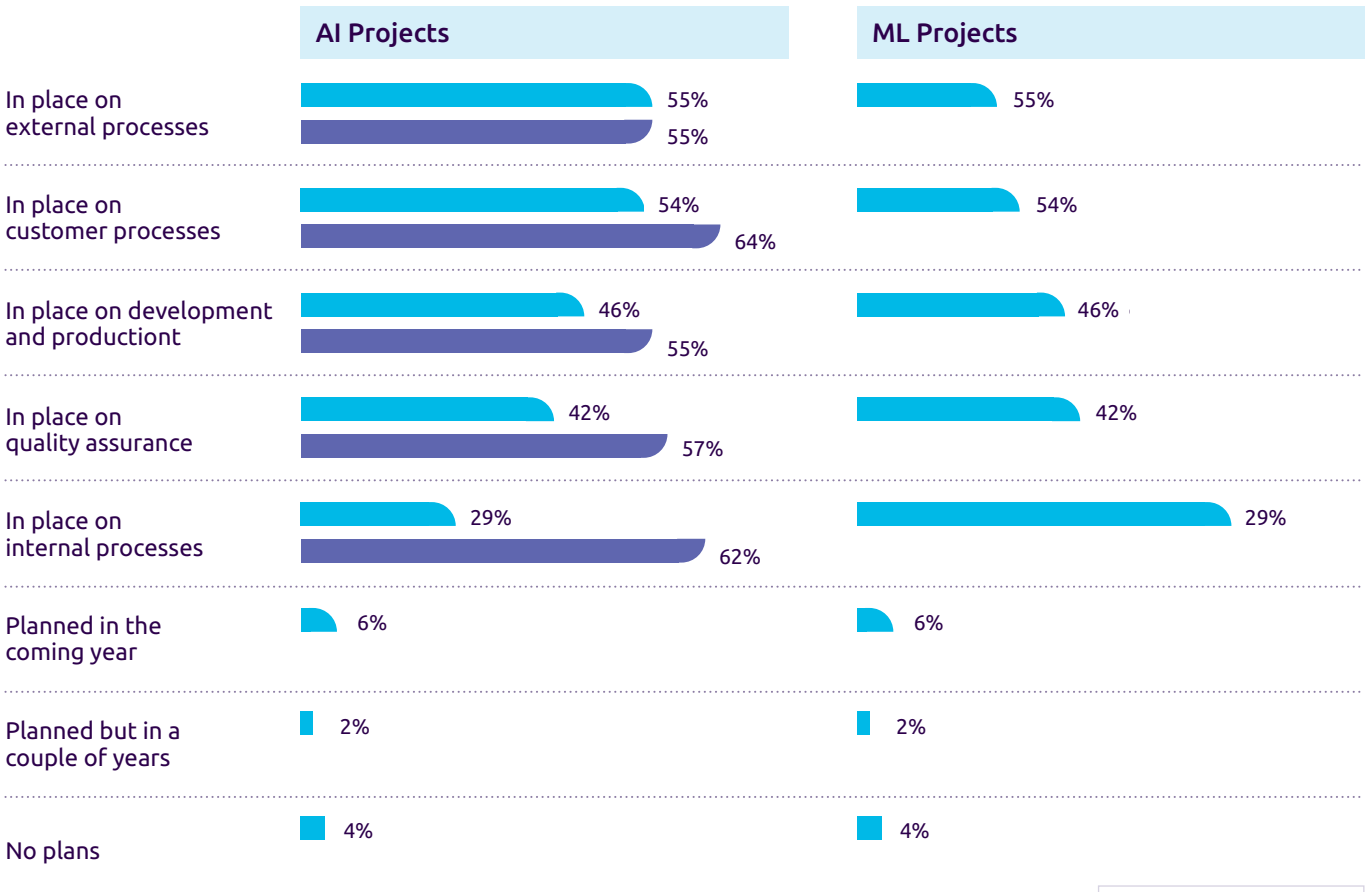
Our experience is that the maturity of these tools is not yet as developed as organizations may like, and the maintenance costs may be higher than they might wish, too. But the early signs are promising; with computer vision, we will see increasing interaction with items under test; and as time passes, AI will be brought to bear on the workload as a whole, enabling businesses to optimize the number of test cases they handle, factoring in risk assessments, and focusing on those cases that are aligned with business needs and with anticipated customer journeys.

The feedback from this year's survey lends support to the assessment. We asked about AI and ML projects that were either planned or in place in various circumstances (see Fig 5). Feedback on AI project commitments was down last year in almost every scenario. This, we believe, reflects the realization that solutions aren't as mature as they were envisaged to be in 2018. We also suspect that some respondents may not be overly fastidious in distinguishing between what constitutes an AI project and what constitutes ML. The maturity of the overall testing function has an impact here.

We find the new data on machine learning interesting. As discussed above, organizations are looking for ways to prioritize their test workloads. With new releases arriving thick and fast, they are using ML to predict likely defects, and to identify which test cases to use. Huge amounts of historical data are needed, and we're going to need to see how well ML mechanisms can learn; but adoption levels are fairly high, and we anticipate them growing.

The proportion of IT budgets allocated to AI projects seems to have dropped somewhat since last year. Although the potential is recognized, it seems respondents are still debating the degree to which they should invest. We suspect that early and general enthusiasm has been tempered by familiarity: people now feel able to make more judicious budget decisions.

Fig 5 Artificial Intelligence and Machine Learning projects or plans for the next 12 months



Previously question not asked for ML Projects

AI, ML, and skills

Responses to questions about the effect of AI on QA and testing skills provide some food for thought. Half of the respondents say they have adequate test strategy and test design skills, and 45% say they have sufficient understanding of the implications of AI for business processes. We regard these figures as optimistically high. Our own experience suggests there is still some way to go in this regard, and the figure of around one-third who admit a skills gap is too low. Skills are needed in development, and also in how to test AI itself: we are still figuring out the extent to which we can explain AI behavior. Figures in this regard in our report show that testing AI does need a rethink.

It is also worth noting that successful AI implementations rely not just on pure AI skills, but also on general business acumen, on non-traditional skills based on statistics and math, and on skills and knowledge relevant to the given enterprise. Indeed, in last year's report we introduced new roles such as AI QA analyst and test data scientist. These roles are still valid, and to implement the right testing strategy, the need is now even greater.

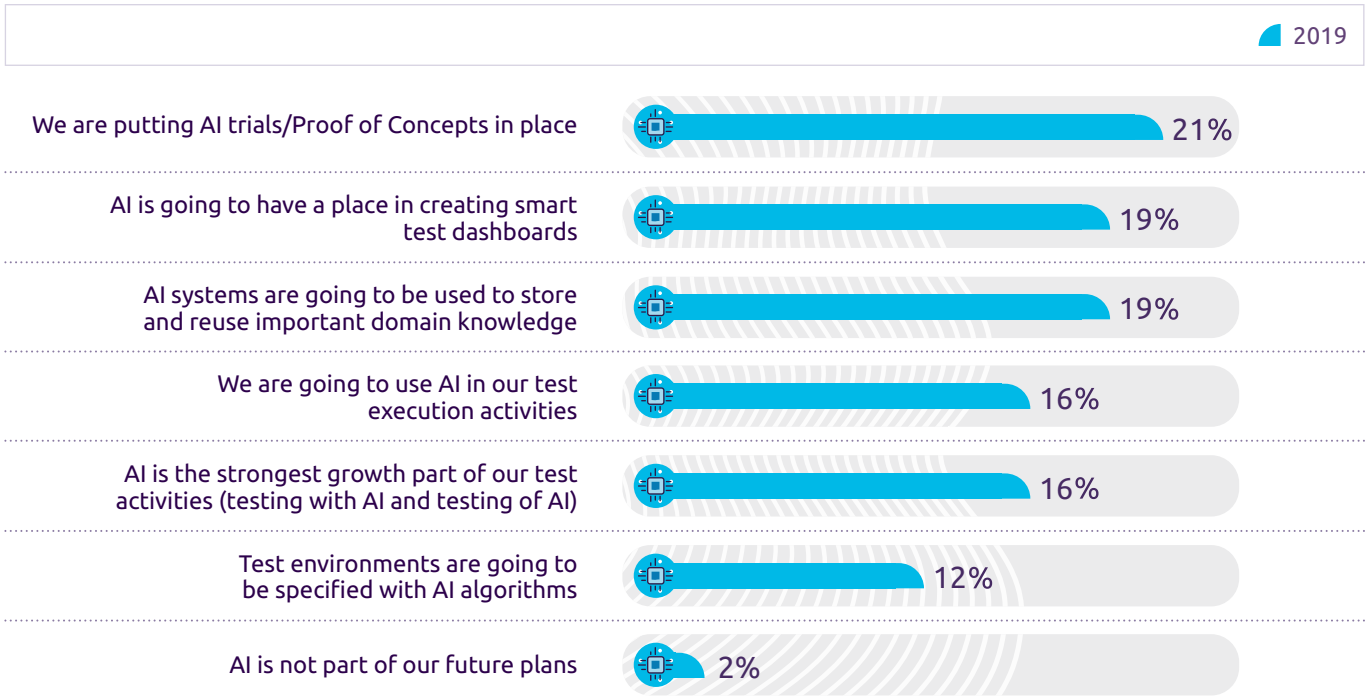
All this is corroborated by respondents' views on the extent to which AI has impacted QA and testing strategy. The two responses chosen by most people as their top option indicate the need for a new strategy, and for a new test approach.

Pragmatism is increasingly the order of the day (See Fig 6). People are running PoCs and reassessing; they are thinking about how best to make use of AI; and they are looking at the budgets.

There is a further sign of pragmatism. Organizations are proactively monitoring and reviewing production logs for incidents, and they are using that information to raise defects before end users notice that there's an issue: 84% of respondents say they are doing this regularly or occasionally, and the remainder say they plan to do so in the coming year. More tools are now available to assist with this. Some of them can not only read production logs, but use them to generate test scenarios. Responding to production activity may seem a little after-the-event, but we regard it as proactive: it's not only practical, but forward-thinking. This was the first year in which this question was asked, so it will be interesting next year to see the extent to which the entire cohort adopts this approach, as they have promised.

Similarly, we asked for the first time this year whether defect leakage into production was being measured, and 87% tell us it is. Will this figure rise? How are organizations reacting to it? Will responses vary by sector, in speed or in nature? What part will intelligent technologies play in tackling it? It would be good to know – but then again, the entire field of artificial intelligence and machine learning is going to be absorbing us from now on, and in just about every way.

Fig 6 Ranking of specific activities with respect to future plans around AI



LeaderSpeak:

Notes from quality assurance thought leaders

Lisa Wardlaw
EVP, Global Chief Digital Transformation Officer, Munich Re

Artificial intelligence (AI) and machine learning are set to transform quality assurance, and interest levels are high. We're seeing increasing commitment to and excitement about implementation – and yet, for many businesses, if not most, these technologies still represent unfulfilled promise.

"Robotic process automation (RPA) is fairly common in finance markets, including the reinsurance industry," says Lisa Wardlaw, EVP, Global Chief Digital Transformation Officer, Munich Re, "but very few are implementing real AI solutions. To assess whether they should underwrite a claim, most organizations are using standard math regression analysis techniques – calculating average values of one variable when others have been fixed, and then repeating the cycle." And they're hiring data scientists to perform these calculations, she says.

Digital transformation…

There are several courses of action Wardlaw thinks organizations in her sector should take. For a start, they should be moving beyond using historical data sets and past decision outcomes regressively for predictive analytics. Instead, they need to adopt a more robust approach to AI, building and using neural networks at levels that current techniques can't calculate, identifying patterns that current processes and people can't see. These, she says, will be the areas of genuine competitive advantage.

A key issue in the use of AI for such assessments is traceability. Regardless of the decision-making methods used, there is a regulatory requirement to demonstrate that decisions are based on evidence, and to eliminate any possibility of bias. Machine-driven decisions tend, in fact, to be less prone to bias, but organizations nonetheless need to prove it, especially with the development recently of bias in algorithms.

Another course of action is to make AI a real and practical component in digital transformation. Wardlaw fills a global role in this area for her own organization, where artificial intelligence forms a key part of quality assurance and testing in software migration and in cloud conversion.

… and skillset transformation

In an area such as AI, where automation is implicit, it is perhaps surprising that human input forms such an important part of the picture. Lisa Wardlaw maintains that people will continue to make significant contributions, but that in order to do so, they will need to extend and enhance their skillsets. The knowledge and experience of data scientists and actuaries will need to be joined by less traditional but complementary strengths in areas such as critical thinking, mental agility and creativity. People at all levels of the organization are going to need to ask themselves how they can take these new creative strengths, together with their traditional data skills, and find new ways of using them – creating new roles for themselves, because any role that involves the input of data, even engineering capabilities, can ultimately be conducted digitally.

At the same time, companies, working with digital partners, may find they are creating an entirely new business model in the process. This, in turn, leads to a further course of action Wardlaw envisages for the application of AI – and this one is perhaps the most radical of all. "In testing, in quality assurance, and also in terms of the very business offer itself," she says, "insurance and reinsurance organizations are going to need to start thinking more laterally, and also more collectively. This business is predicated on digital processing, and the data on which it acts is being created elsewhere, in other disciplines, in other markets. Ultimately, it derives from the actions and needs of consumers. Artificial intelligence makes it possible to create a layered model in a single value chain, interpreting and acting upon data to create new products and solutions we might not yet even be able to envisage. Financial services organizations may think of themselves as distinct and separate, but consumers think differently. They expect holistic solutions, with financial services elements as an integral part of the package."

In financial services markets such as reinsurance, artificial intelligence may still only be a promise – but when that promise is fulfilled, the industry will never be the same again.

Intelligent automation

The pace of development in test automation shows no signs of slowing down in this year's report.

Rajesh Natarajan
Director, Digital Assurance and Quality Engineering, Sogeti, Capgemini Group

Chaitali Lambat
Senior Manager, Digital Assurance and Quality Engineering, Sogeti

Deepika Mamnani
Senior Director, Financial Services Capgemini

Ramesh Ayalasomayajula
Senior Manager, Digital Assurance and Quality Engineering, Capgemini

Vaishali Jayade
Director, Digital Assurance and Quality Engineering, Sogeti

Overall, we're seeing high levels of regression automation and of UI automation, as well as growth in model-based testing (MBT) and of course in robotic process automation (RPA). A key factor is the design of automation frameworks that are resilient, particularly because the business context in which developments take place is so subject to demand, and hence also to the need for pace of change.

Figures this year, including for testing activities not previously covered by this report, show automation plays a role in every case. Where historical data is available, the trend is upwards; where it isn't, the figures are even higher. For example, respondents report that 19% of user acceptance tests are being automated. It's a useful indicative figure, because it shows that business has accepted the premise of automated testing, which is a promising sign.

In our view, while the numbers may be rising, they don't reflect the adoption levels we are seeing. What's more, we expect all of them to increase further, and for artificial intelligence (AI) and machine learning (ML) to accelerate the pace of adoption and also to improve outcomes.

Automated proportions of activities logged in previous years are likely still to be increasing, too. Automation is, in short, increasing across the test spectrum: everyone is ultimately working hard to achieve its application end to end, even though figures for end-to-end business scenarios dropped slightly in 2018 (down by one percentage point to 15%).

As part of this, we note significant growth in the use of Open Source automation tools. This is happening in upstream development as well as in traditionally downstream testing, and as continuous testing becomes a reality, we can expect to see these tools become seamlessly integrated into the pipeline. Indeed, sales of some commercial products are decreasing. It's not just a cost issue: people like the flexibility they offer, and the fact that there is no rigidity on licensing. They also like the support they share with others as part of the Open Source community: there is real traction here, with benefits for all.

The challenges…

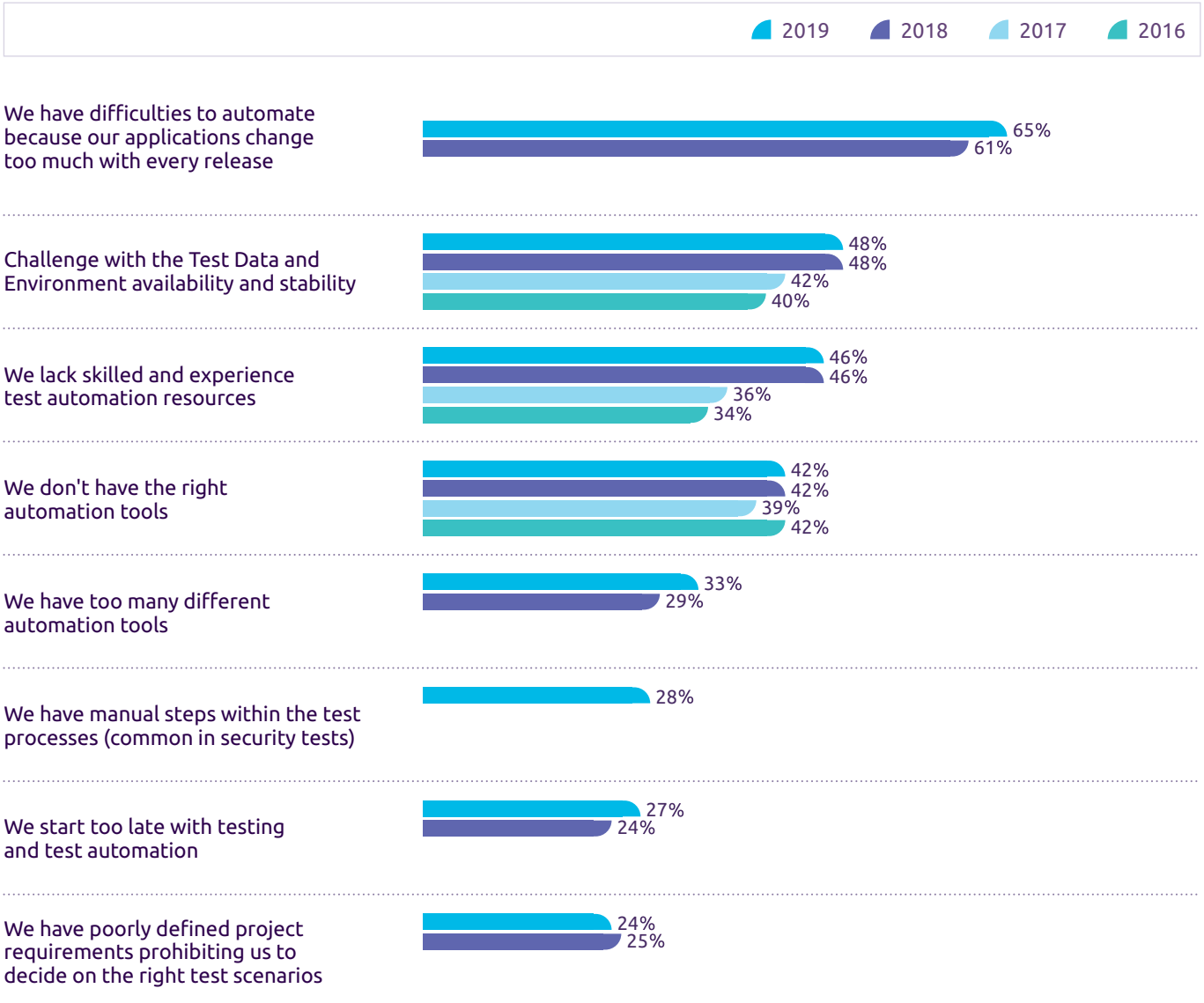
The main challenge faced by organizations seeking to automate testing is the great volume of their business demands, and the speed with which those demands are growing and changing. Almost two-thirds of respondents report that they have difficulties in automating because their applications change too much with every release (See Fig 7). It seems to be getting worse: the figure is up from last year.

In our view, the key issue here is that the market has not yet been sufficiently able to embrace DevOps. It is difficult to integrate test types in the delivery pipeline, because of diverse technology stacks, tools, and the speed of releases.

Also, test data and environments remain a key challenge, as indicated from previous years. In short, automation may be on the rise, but it can't keep pace, because the techniques and tools are insufficient to cope with the typical volatility of business demands.

Other significant challenges noted on this slide haven't changed greatly since last year. In particular, the availability and stability of test data and environments, the need for skills and resources, and the lack of appropriate automation tools, all indicate that the testing industry is still struggling to find the best approach, as well as the tech and HR resources to match it.

Fig 7 Main challenges in achieving desired level of test automation



New tools are of course available, and they're evolving, but they are still not fully addressing our respondents' challenges. For example, we know scriptless tools can quickly adapt to changing applications demands – and so if, as our survey shows, people are still struggling, it perhaps suggests these tools aren't yet sufficiently mature.

What's more, a third of respondents say there are too many different automation tools – an increase on last year. It's true: many tools don't work well together, and that sometimes necessitates the introduction of manual processes.

That's why it's interesting to note that a new option among the challenges this year was: "We have manual steps within test processes." More than a quarter of respondents acknowledged this challenge. We do, however, see this as an issue that is likely to diminish. As organizations move increasingly towards DevOps, and the methodology matures, so these steps will reduce. The core development community will address those manual steps that remain, and pressure from this group will, in time, result in further action from those actively engaged in automation development.

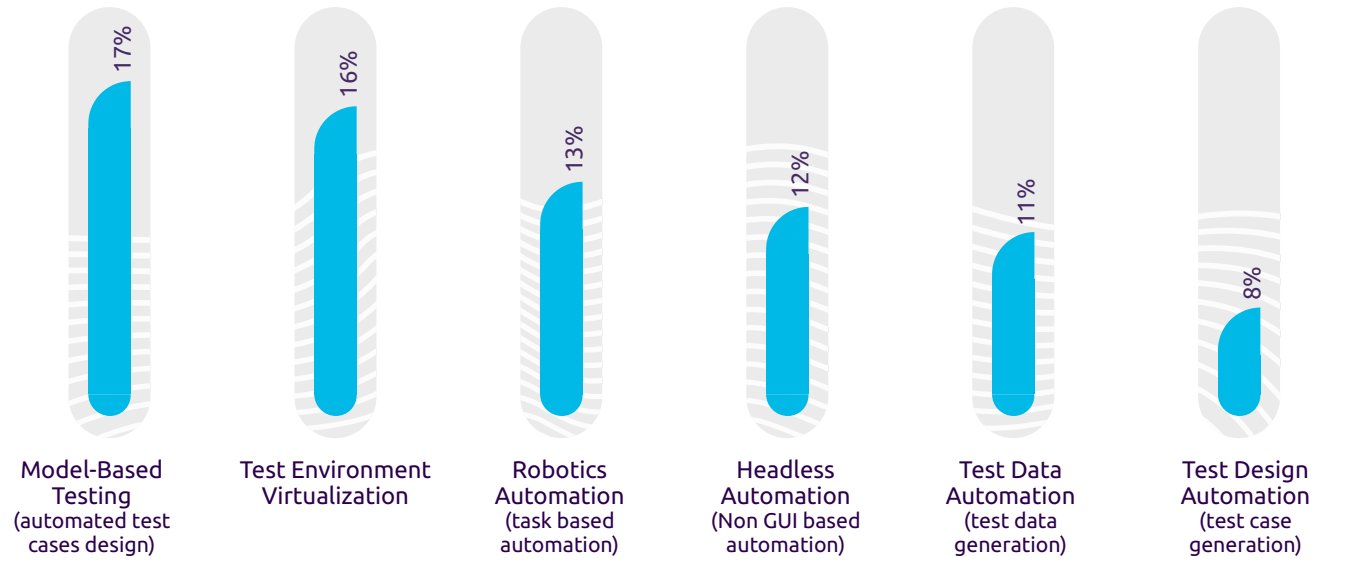
Incidentally, while "we start too late" appears near the bottom of this list of challenges, the figure hides quite a degree of variation. It's significantly higher in some sectors – notably, in the high-tech and communications industries, where newer technologies emerge faster and more often than in other industries, creating more daunting action lists.

… the skills need…

Separate figures in the survey, new for this year, show the challenges organizations are facing in adopting higher levels of automation. The suggestion that polls at the bottom is: "Our teams do not have the right level of test automation skills and test tool knowledge." In our view, this figure is too low, and when we consider the new techniques people foresee using in the coming year (See Fig 8), we see there is a clear shift towards intelligent automation, with organizations realizing that it is important to automate tests related to architecture. This explains the use of model-based testing, as well as the use of machine learning techniques to learn what to automate. Robotic process automation for task-based automation provides an alternative to GUI automation. The ultimate aim here is to build the skills necessary to design frameworks that are resilient, from a code, data and script standpoint.

That said, with new automation tools, management can't always assign the right people with the right skills to the right teams. Indeed, the availability of the right automation tools and frameworks was the most commonly cited challenge. It's worth noting that it's not only new developments that need access to the right tools – legacy systems do, too.

Fig 8 Projected business interest in automation techniques in the coming year



… and the benefits

Despite the challenges, organizations are positive about the benefits that accrue from test automation – and that feeling is growing year on year (see Fig 9). Expressed as a percentage, the value of all benefits is trending upwards since 2016. What's more, that value is pretty much equal, whether it's for defect detection, test cost reduction, or reduced cycle time.

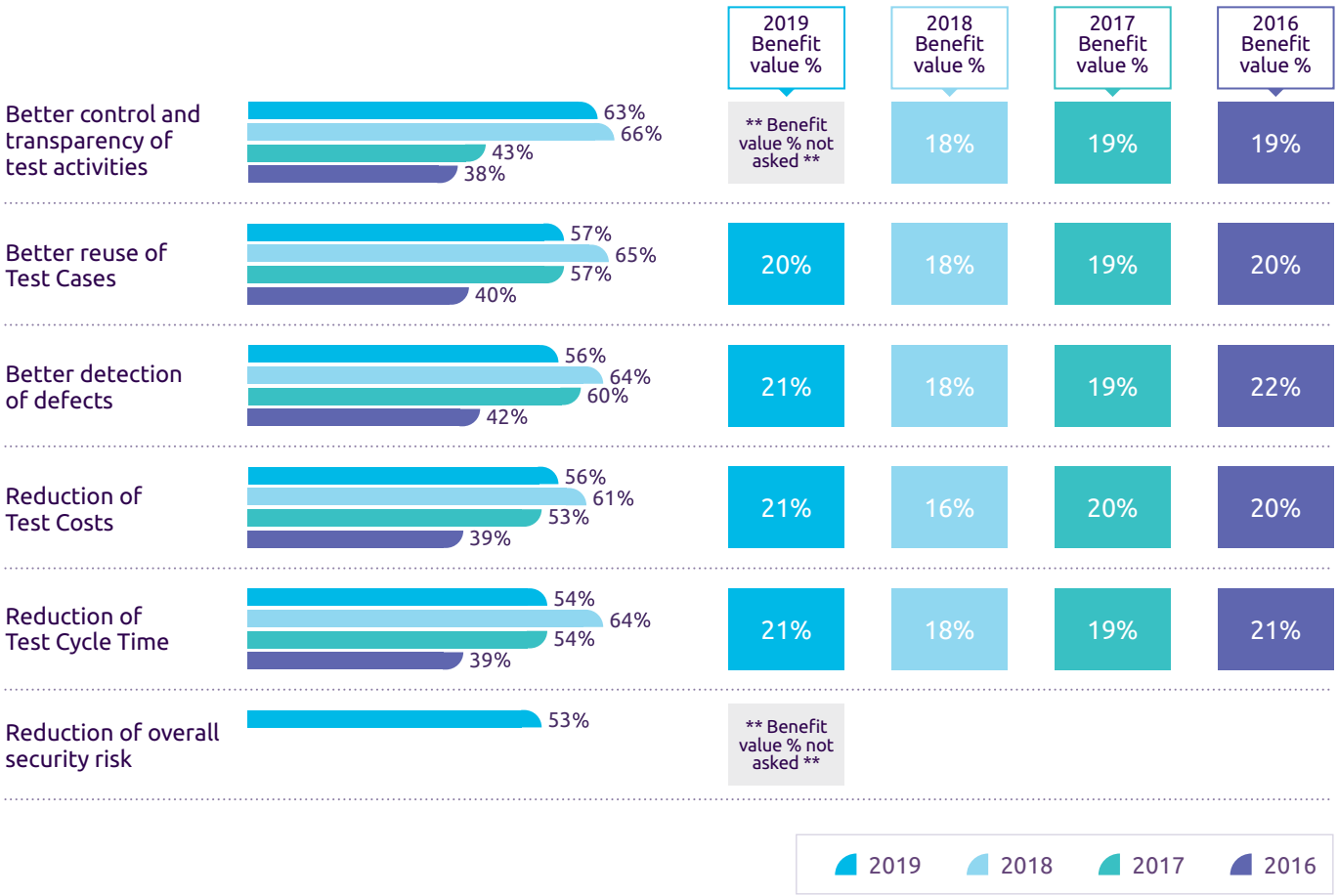
Look more closely, however, and you'll see that actual benefits, as opposed to perceived value, have dropped from 2017 in each case. It's a sign, perhaps, that new automation tools aren't yet keeping pace with the general technological developments they address, nor with business priorities. That said, we may find that tools and processes being introduced now will be bearing fruit in future reports.

How will organizations get there? We asked people to look ahead, and to specify the skills that will be key for next-generation automation engineers. Development skills and behavior-driven development (BDD) ranked highly, but we were surprised to see machine learning skills appear only half-way down the list. We're confident that skills in this area and in artificial intelligence will be in increasing demand as the years pass.

API and Microservices, which should be the most automated area typically, are surprisingly at the bottom. This may be due to fact that API automation with new scriptless tools does not need any coding skills.

Last year, we also asked people to look ahead to the automation techniques they would be using. The top three answers we received back then were model-based testing (automated test case design), predictive analysis, and robotics automation, and we continue to have great expectations here – and also for self-remediation, which polled surprisingly low in 2018.

Fig 9 Benefits realized through test automation



Building for the future

In summary, test automation has been around for almost two decades now. A key reason why organizations have not been able to get the desired return of investment from automation initiatives is because most frameworks were designed to automate manual steps, but were not intelligent. They were unable to react to changes, dynamically generate the resources they needed, or understand and interpret results. This has led to significant maintenance effort, particularly at a time when software changes are extremely frequent.

In our view, progress in test automation will be made if people think of it less as a capability, and more as a platform – as a broad, connected, and intelligent space. When all tools and functions occupy a common environment, they can talk to one another to drive a full lifecycle value proposition, rather than remain focused just on one particular activity. When that point is reached, test automation will be smart, and broader, business-driven benefits can be given the priority they deserve.

Here are our recommendations for designing smart automated frameworks:

1. **An intelligent automation framework is intuitive:** it can check the code and create appropriate automated tests corresponding to the code changes
2. **An intelligent test automation framework is dynamic:** for example, it can use cognitive computing techniques to identify and screen elements dynamically, and update object repositories
3. **An intelligent test automation framework can generate its own environment:** for example, a framework can spin up environments at run time through machine-readable definition files
4. **An intelligent automation framework can prioritize:** a good use case for this is a framework that can identify and execute critical test cases from an automated suite, to achieve high defect yield per test case execution using algorithms such as Random Forest algorithm
5. **An intelligent automation framework provisions its own test data:** the data can be provisioned either by virtualizing, sub-setting, or creating synthetic data.

LeaderSpeak:

Notes from quality assurance thought leaders

Interview with the Global Testing & SQA Director at a global life sciences company

For some years now, the World Quality Report has been tracking the adoption of automation in the test environment and in quality assurance (QA). The figures may be growing, but many of the concomitant challenges aren't going away.

The Global Testing & SQA Director at a global life sciences company cites two obvious and significant examples. "Cost is, of course, a challenge in test automation," he says, "and so is perceived value. Automation, and the use of new technologies such as artificial intelligence (AI) and neuro-linguistic programming (NLP), can reduce effort and resourcing, and so deliver cost benefits – but these have sometimes been hard to quantify and demonstrate, especially to less technologically aware people in the organization. Fortunately, things are changing now. Understanding is increasing with familiarity, and at this organization, our own proof-of-concept exercises are helping."

This report shows the importance organizations are now placing on the identification of the test areas best suited to automation, and the company in this case provides a good example. "ERP has been a big focus area for us," the testing director says. "It's a key platform, and automation here can make a great difference both in our progress and in the value we achieve. Finance and HR are also significant areas. The clinical trials function is specialist, and presents its own challenges, but we may look here, too, in the near future."

Robotic process automation (RPA) may not be in the upper part of the intelligence spectrum, but, says the director, that doesn't mean it lacks value. Far from it. "It's an important first stage in broader automation efforts," he says. "Implementing RPA helps organizations start to see their processes in a new way. It enables them to lean out, as it were, and rethink implicit test automation responses."

Blurring boundaries

This global business exemplifies another trend visible in this report – and that is the extent to which functional and development resources are increasingly merging with testing. The boundaries are blurring, and that, in turn, means broader skillsets are needed.

"Quality is everyone's responsibility," the testing director says. "Like most businesses, we want to expand – so everything needs to be known to work, which means in turn that everyone needs to be able to automate. If testing is merging with development, it shouldn't be a specialist discipline any longer. At strategic levels, sure, there ought to be specialist insight; but at tactical and functional levels, skillsets need to cross-pollinate."

The multiplicity of tools is a further challenge. "The pharmaceutical industry uses so many," the test director says. "They are largely enterprise-wide, and highly standardized. This can be a problem, in that there is potential for innovation to be stifled. But on the other hand, freewheeling innovation can be uncontrolled and worrisome. So it's a constant trade-off, in which we push for benefits, and mitigate as much as possible against risk."

The company's testing director believes making long-term predictions in a fast-moving world may be unwise – but in the nearer future, he anticipates a growing ability of testing tools to analyze and report, especially by exception. He envisages AI functions being able to determine what companies will want to do, and automatically start to build the appropriate test cases. "Typically," he says, "test automation is bolted onto developments after the fact. It will be far better when it's factored directly and fully into business process design, so that it becomes an integral part of the proposition."

For the company in this case, another integral element has been the business relationship with Capgemini. "As we move to a managed services model, we're going to depend even more on the service and knowledge of our partnership with Capgemini. We're pushing hard towards greater and more beneficial QA automation, and we don't want to lose any of the momentum we've achieved."

Test data and environments

The World Quality Report survey indicates that nothing much has progressed with test data and environments

Andrew Fullen
Solution Director
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Shivakumar Balasubramaniyan
Vice President
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For some years now, businesses have recognized the importance of test data and test environment management (TDM and TEM). Nothing has changed in this respect.

Sadly, though, nothing much has changed in terms of progress, either. In our experience, decision makers in many major organizations seem content to live with current circumstances. The status quo is a known quantity, and it provides a sense of security. Businesses don't seem fully to appreciate the benefits that change might achieve, nor the savings they could make. Advocates of change tend to be in lower roles, and don't currently have sufficient clout to make things happen.

However, change will come. Arguments in its favor are irrefutable, and if IT departments don't themselves take steps, they may find the decision being made by others. For example, we are increasingly seeing the provision of TDM and TEM on an as-a-Service basis.

Alternatively, IT departments may find they need to restructure. Right now, test environments sit uncomfortably in a no-man's-land between operations and testing. They could instead report directly to company CTOs, breaking down barriers, and helping to make designing, testing, and building a dynamic, continuous, and flexible process.

Test environments in the cloud era

This year's survey provides interesting pointers to current attitudes and trends. For example (see Fig 10), 20% of respondents' testing is said to occur in cloud-based temporary test environments, while 30% – half as much again – takes place in a traditional, permanent test environment. We find this surprising, particularly when we also note that the figure for temporary environments has been trending downwards in recent years, from a high of 27% in 2016. Cloud-based environments are flexible and transparent. They enable test teams to check whether instructions are accurate and up to date, whereas permanent environments are more monolithic and unknowable: you can't tell what patches have been made, nor what problems may have crept in over time.

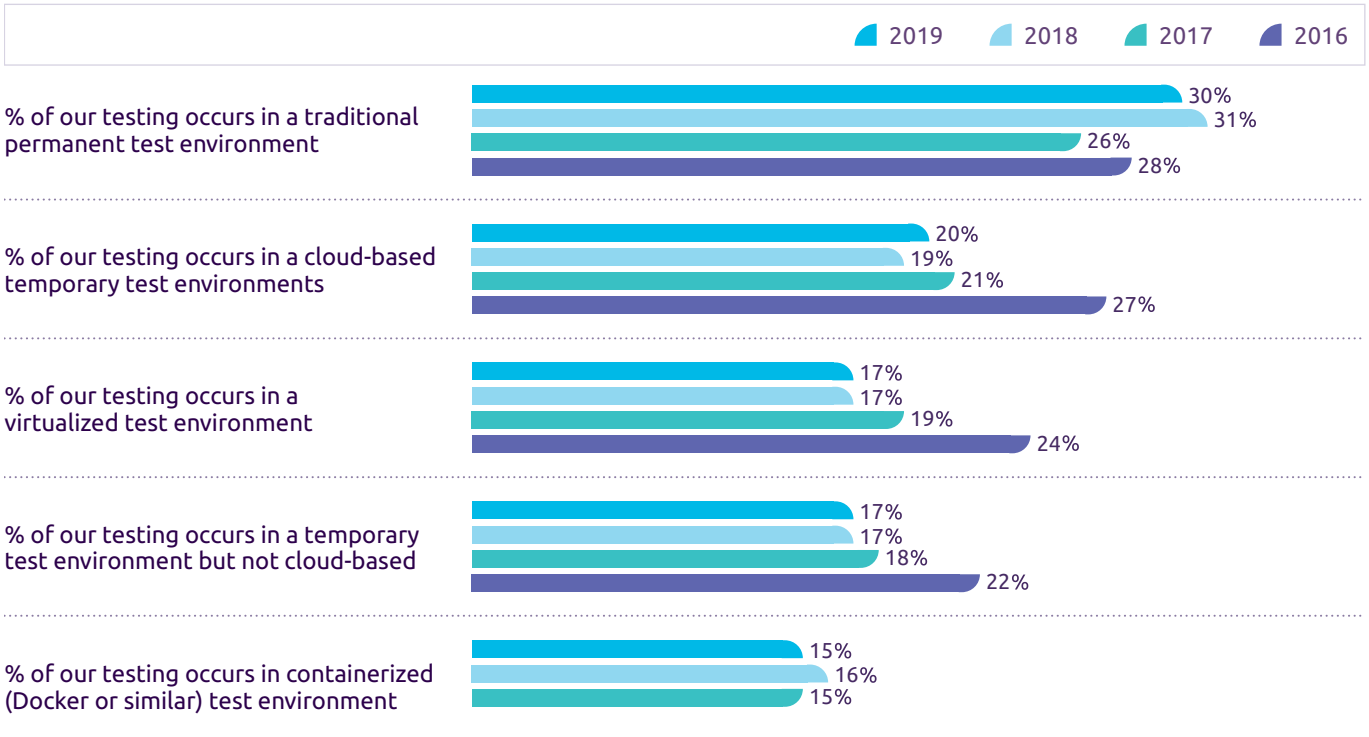
It's odd, too, that virtualized, containerized and temporary-but-non-cloud-based test environments have all moved so little in recent years, and indeed have, in general, trended downwards – particularly when the tools that drive these environments have moved on a great deal. We see that more mature organizations have started leveraging dockers and containers for test automation, as they can establish multiple test environments for automation in the cloud for parallel runs.

Respondents were asked about the types of testing they perform in cloud-based test environments, and the three most popular are performance testing, functional testing of cloud services, and security testing, at 63%, 61%, and 58% respectively. As we might expect, these are areas that have benefited from cloud environments, and indeed the trend for all three has been moving up in recent years. This is partly due to an increase in customers leveraging many commercial off-the-shelf products that are in the cloud in an as-a-Service model. For example, many policy administration systems and marketing solutions offer cloud-based solutions with largely out-of-the-box configurations, resulting in a need to create similar cloud-based environments for testing.

It is also notable that there is little change in cloud-based testing as far as the functional testing of business intelligence and business analytics solutions is concerned. Nor is there much change in the functional testing of core enterprise packages, such as the major CRM, ERP and financial system platforms. We suspect the temptation here is to retain a sense of ownership of what are seen as the corporate crown jewels – even though to do so is (a) to hold a mistakenly negative view of cloud-based approaches, (b) to forego their potential benefits, and (c) to delay preparations for the major and inevitable transitions that some of these platforms will soon require – in ERP, in particular.

Of the challenges posed by test environments, the greatest by some distance is cost. In 2017, 39% of respondents mentioned it; this year, that figure has risen to 60%. The

Fig 10 Proportion of testing in each type of environment

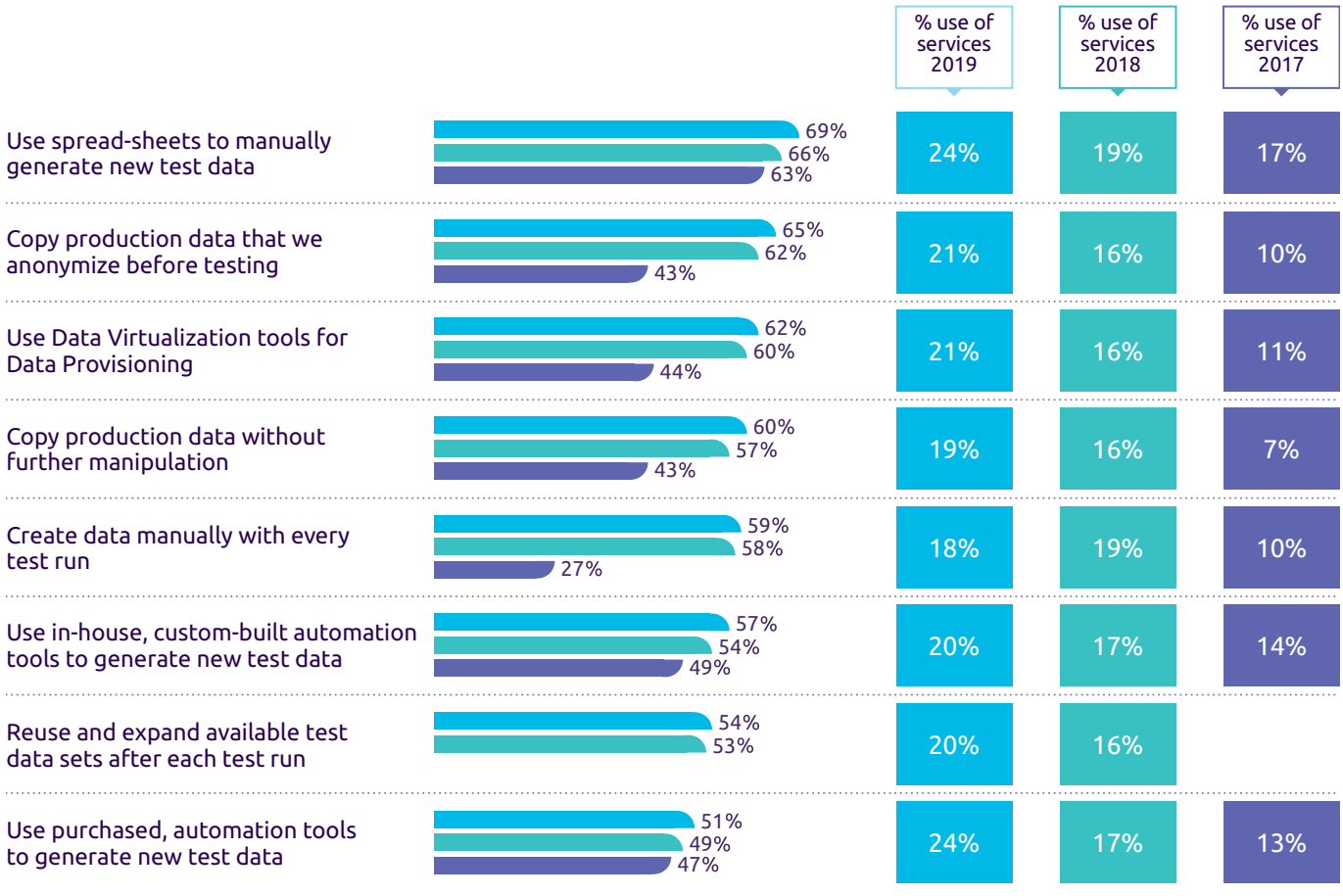


growing demand for test environments for various types of testing, as well as the increased need for availability of non-production environments, are two reasons for these rising costs. With luck, if non-production environments move to the cloud, the ability to scale up and scale down environments when not in use can bring costs down. It will be worth tracking this trend next year to see if this continues to be a challenge.

The lack of visibility on what can or cannot be tested in incomplete test environments is interesting. This will be a challenge for agile projects, where end-to-end testing happens across scrums. This requires collaboration across scrum teams for the application under test and for the supporting environment. In the SAFe ™ methodology, the concept of a systems team will to some extent be able to address this issue by orchestrating end-to-end testing and the planning and coordination of the environment early in the lifecycle.

Defects caused by the inaccurate configuration of test environments also feature as a challenge. (In our experience, people are indeed more aware on that score these days.) So, too, does the lack of visibility into whether a test environment is available. This is surprising when it is an issue that can so easily be resolved: post a page akin to an online travel booking system, and the job is done. Perhaps the perennial problems of cost and time are to blame. In fact, it's likely that all test environment challenges have a significant cost element.

Fig 11 Methods of provisioning and generation of test data for multiple iterations of testing and the proportion in which they're used



Approaches to test data

We asked respondents about the challenges they face when managing test data. Maintaining data consistency and creating/maintaining test data that are not copies of production data will continue to be a challenge. As we have seen with artificial intelligence and machine learning (see earlier section of this report), releases are fast-paced; requirements change frequently; operating environments can multiply; data cuts across systems; and organizations need to take a holistic approach at an enterprise level to truly make it meaningful. This is a critical capability that is worth a center of excellence approach to deliver test data on an as-a-Service basis to the scrum teams in an agile model.

Many financial services and insurance carriers in particular are leveraging new types of data that they have not traditionally seen or leveraged for their business. This data is coming from IoT, analytics, cyber, and social media, giving rise to the tailoring of products to customer preferences that will require new ways of creating and maintaining end-to-end test data.

How are organizations provisioning and generating their test data? From our responses (see Fig 11) we can see that several approaches are being employed. The first two methods shown on the graph are trending upwards, and in Europe, the need to work within GDPR conditions may well be a factor here.

One of the most interesting takeaways from this slide is the general sense it gives of attitudes to data. In-house strategists and external analysts and advertisers and others may all recognize its significance – but here, there seems to be little appreciation of its value, either in quality or in the potential of its overall volume. It's no surprise, therefore, to note that elsewhere in our survey, as many as half of all our respondents felt that no change was needed as far as skills were concerned, in areas including software development engineering testing and data science. People still don't seem fully to understand that data truly is the engine that drives the business, and that this has implications at every level, including in test environments.

There is one last point that can be made here, and that is to note the high value given to the manual creation of test data. This is surely worrying. When data is so fundamental to people's lives – to decisions about jobs, and loans, and insurance, and health – it is essential that the methods used to test it can be depended upon to be robust.

To conclude, then – organizations both want and need to achieve progress with their test environments and test data. Perhaps the best way they can do this is to challenge their own status quo – in which case, it may be a good idea for them to obtain a fresh perspective. Sometimes, we all need an independent observer to point out something we're either too close or too engaged to see for ourselves. That may well be the case here. Note to self: seek and find a critical friend.

When data is so fundamental to people's lives – to decisions about jobs, and loans, and insurance, and health – it is essential that the methods used to test it can be depended upon to be robust.

LeaderSpeak:

Notes from quality assurance thought leaders

Sofia Choudhry
IT Director
The Coca-Cola Company

Several significant trends have been emerging in this year's World Quality Report, and some of them have been reflected in the LeaderSpeak pieces we have inaugurated this year.

Coca-Cola is a case in point. For example, the shape of the quality assurance (QA) structure at Coke has changed. "It used to be centralized," says Sofia Choudhry, IT Director, The Coca-Cola Company. "We had QA centers of excellence (CoEs) for our SAP-specific and non-SAP functions. On our journey to digitize our enterprise, our supporting tools, processes, and frameworks have been re-imagined. Agile and DevOps developments have become central to our transformation. So now, we find that, rather than having a single and comprehensive CoE, QA is less discrete. It's more embedded in individual teams, as part of the overall development process. Yes, we're still looking to retain a CoE function, but it will be lean. Its prime function will be to hold the ring on enterprise-wide issues such as governance."

As we might expect, there is a strong alignment at Coca-Cola between the business and what the company calls the 'voice of the customer.' Consumer demand drives not just marketing, but product development – the next generation dispenser is an example – and it also impacts QA decisions. Coupled with the rise of agile and DevOps, it's resulted in shift-left, with quality assurance processes becoming integral at earlier parts of the operational cycle.

The adoption of agile and DevOps at Coca-Cola has led to a need for a formal and scientific approach of managing the test environments and test data. Challenges have included ensuring the integrity and currency of test data, the masking of sensitive data, data location, and refresh time issues.

"We have experienced issues managing our test data while validating large/integrated platforms like SAP," says Choudhry. "For example, the mining and setting up of test data took up around 30% of our regression testing efforts. Constrained by the limited test cycle window, it was getting difficult to run full regression cycles in spite of having an automated suite. We were able to address this challenge to a great extent when we modernized our automation scripts and included the data mining and set-up steps within the automated suite."

"We've also experienced issues," Choudhry says, "with test data drawn from production – not just in terms of its currency, which I've mentioned, but also in terms of the quantity of data available to us. If we're running tests for our commercial customers, we need to be sure we have enough up-to-date data for each of them, and perhaps for each of their given locations, too. Also, those integration issues to which I just referred haven't been made any easier in some cases by the transition to SAP S/4HANA. It's quite a challenge, as I say."

Lean at the center

Part of the solution is the lean Center of Excellence in test data management that Coca-Cola is considering. "It will need to be more efficient," says Choudhry. "It will of course need to meet business demands; and it will need to keep our test data and test environments in line with our IT strategy as a whole."

Coca-Cola is looking at tools that can help to make all this happen. Key criteria, Choudhry says, include:

- Automatic data masking / privacy
- The ability to analyze and validate data before testing
- Faster data copying from production into the QA environment

More testing is happening in the cloud now, in large part because that's where all Coca-Cola enterprise apps now reside. It may still be early days, and the company is assessing its approach and its best level of engagement, but nonetheless, Choudhry says, the consumer and retail side of the business is blazing a trail here, and is set to optimize costs in the process. "Mimicking the performance environment to that of production has been a challenge," she adds, "but with the move to the cloud, we feel we're getting there."

Cohesion and partnership

For Coca-Cola, the main TEM and TDM issues include the movement towards an overall strategy for testing and QA in the context of developments in agile and DevOps, and the need to support the company's digital transformation. "We're working on it now," Choudhry says. "We're aiming to bring it all together in a way that will give us a complete view, with enterprise-wide governance, and with a comprehensive approach to test environments that matches our current and future needs."

The security imperative

For the first time this year, security was included in particular as a separate theme in the context of the World Quality Report

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The topic of security and risk compliance doesn't always have its own dedicated section in the World Quality Report. Last year was a case in point. But it's nonetheless an area that continues to command our interest and attention. Every year, it features frequently in discussions around key themes, as well as in our sector and country reports; and this year, we're also featuring it in its own right, as well as articulating it specifically in some key questions.

A general trend that is noticeable in this year's report is the growth in agile and DevOps developments; and over the last year, we've been seeing how security testing can work in this context. It's a subject to which we'll return in a moment.

Another pertinent factor is the EU's General Data Protection Regulation (GDPR), which came into force in May 2018. It represents the biggest data protection challenge in over 20 years, and is therefore also a significant software compliance issue – not just for businesses and other bodies in Europe, but for any organization anywhere in the world that holds data on EU citizens.

Security trends

For the first time this year, security was mentioned in particular as an overall objective in the context of quality assurance (QA) and testing. While this means we shall have to wait until next year to start analyzing trends, its inclusion this time does enable us to note a few key points about the extent to which it is deemed significant. These objectives include:

- Increasing awareness of the importance of security among all disciplines
- Implementing security checks earlier in the lifecycle
- Increasing the security of software and products

We also note that, among technical issues in current applications development, challenges with security validation are cited by more than half (52%) of respondents. What's more, security tests rank alongside usability, systems integration, performance, and other test types in terms of the proportion of time spent on them – and in addition, over one in four respondents (26%) say that agile and DevOps developments have changed their security skills requirements and created a greater need. It's clear, therefore, that this is indeed a top-of-mind concern.

Automating security tests – and moving security tests to the cloud

Our survey respondents were given a range of different test types, and they were asked about the extent to which each type was being automated. We are surprised to see that security is the least automated testing type, with a level of 13% of this activity being automated. While it is our own experience that much security testing is indeed still manual, this low figure is not what we see in the field. There is a real appetite for automation in this area. It reduces errors and increases test quality. It's faster, and it's also more comprehensive than manual methods, meaning that it can test more sprints and larger data sets with better accuracy. Indeed, more than half our survey respondents (53%) report that as a result of automation, they have seen a reduction in their overall security risk. It's a good figure, and one that we expect to rise over time.

A challenge here is that some steps in test processes have simply had to be manual, making full automation difficult. It's an issue that arises particularly in security tests. More than one in four respondents this year (28%) say this is the case for them.

What's more, the skills and tools needed to perform security testing are very different from those that testing teams currently have. Essentially, testing owners need to acquire these skills quickly, or to look for experts from inside or outside the organization to drive this for them.

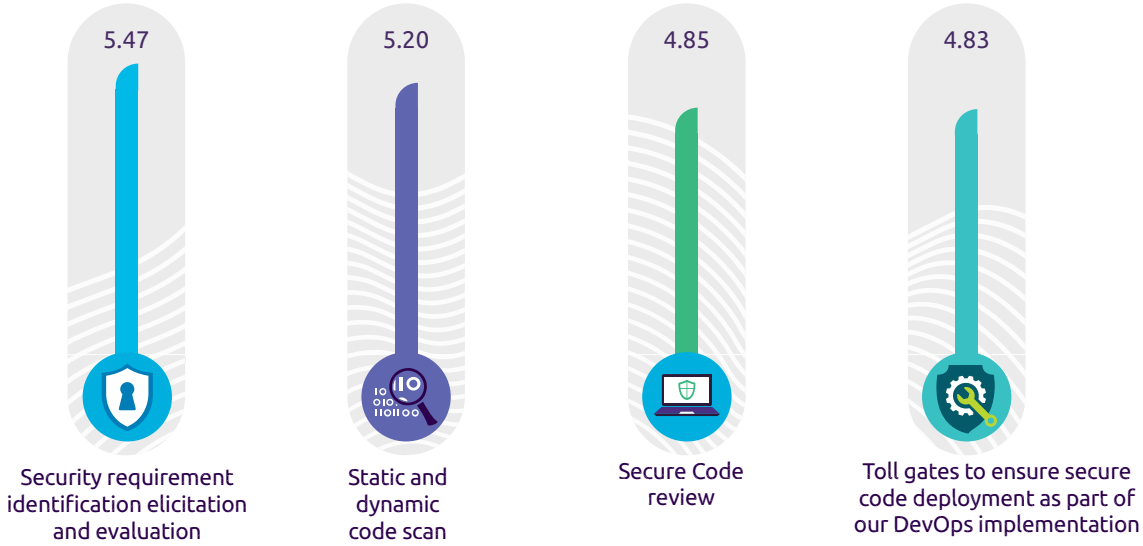
Over recent years, we have seen test environments increasingly move to the cloud, and the field of security is no exception. Since 2015, levels of security testing being performed in this way have risen from 42% to 58%. Organizations are clearly happy with the approach, and we feel it distinctly possible that this figure will rise to around 70% next year.

Secure development strategies

Fig 12 shows, the strategic aspect deemed most important and the average score given to each category. Reading from left to right, we see that the focus is on those aspects of security that come earliest in the lifecycle, and less on those that take place later in development. Static and dynamic code scans are important elements of that lifecycle, so their high position, second only to identification, elicitation and evaluation, is only to be expected. These results are another validation of the importance of security by design, and the value of running static and dynamic security tests earlier in the development lifecycle.

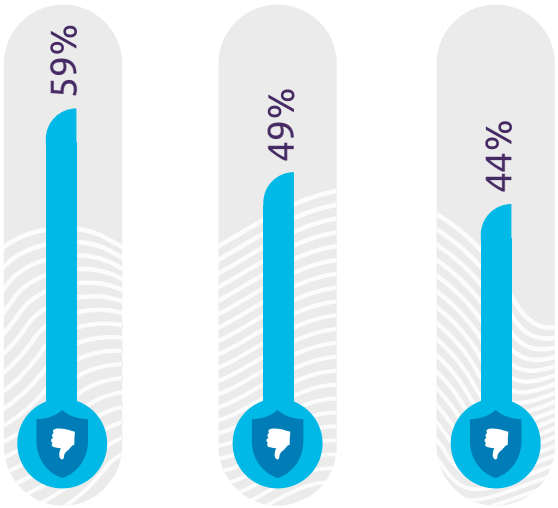
A further new question this year relates to security challenges (see Fig 13). Effectively, what we see here, left to right, are challenges relating to the practice, the principle, and the architecture of data security, with practice representing the greatest challenge. It tells us, in a sense, that most of us know what to do in theory about their data security, but that we are having difficulty with implementation.

Fig 12 Ranking the importance of certain aspects of secure development strategies



We are a little surprised that design deficiency didn't attract a slightly higher score to bring it closer in level to the data policy challenge, but that said, all the figures are rather high. If we revisit this question in years to come, it would be good to see overall levels dropping here.

Fig 13 Challenges experienced in securing data



Looking ahead

Secure development, quality assurance and testing will always be work in progress, because risks will continue to evolve, and so will the regulatory environments with which organizations need to comply. Worldwide, we are seeing more political pressure for greater security, necessitating more testing and higher levels of compliance. In some geographies, it also means that more certifications are required. We expect to see this trend continue for at least the next three to five years. There will also be greater levels of scrutiny and more stringent requirements in specific areas: the development of CASE vehicles (connected, autonomous, shared, and electric) is a good example.

Risks will especially continue to evolve in the realm of cyber threats. Prime actors in this space could be civilian groups who act in support of certain governments, their own personal benefit or in pursuit of their own political agendas. Other perpetrators could be organized crime groups, or foreign powers.

Whatever the case, organizations worldwide will need to address and mitigate these threats, and protect not only their intellectual property, but the third-party data they hold – and that could include the personal data of their customers.

Security is, in short, a significant and constant challenge, but in a digital world, that's the price that must be paid to be in business.

Cost-containment and efficiency in QA

In a fast-changing test and QA environment, costs need to be optimized – but without compromising quality

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Micro Focus

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Maheshwar Kanitkar
Senior Director, Digital Assurance and Quality Engineering,
Sogeti, Capgemini Group

Previous WQR surveys have shown fluctuations in QA and testing spends. Causes of this fluctuation have included investment in digital transformation, the introduction of new testing tools and technologies, and overall performance differences that organizations can achieve over time.

Indeed, cost is the main obstacle in the path of QA. If quality is non-negotiable – and it is – how can costs be reduced, or at least, managed? And how can quality continue to be delivered not only within budget constraints, but at the pace required?

Key factors

There are a number of factors affecting cost and efficiency. One of them is the rise of cloud computing – perhaps the most flamboyant innovation so far in this century (although that title is likely to be taken soon by artificial intelligence). The cloud has a bearing on how enterprises organize themselves and manage their infrastructure and their business propositions – all of which has cost implications. It also directly affects the market they serve: what increases efficiency for the business also increases flexibility and ease of access to information for customers.

Another influential factor is virtualization. By creating virtual turnkey systems, comprising servers, storage, databases, applications, and more, organizations are streamlining their infrastructure, optimizing its utilization, achieving greater efficiency, and lowering their costs.

The rise of agile and DevOps development is covered extensively in this report, and it's also a factor here, in a cost-efficiency context. These environments break down siloes and integrate QA to enable efficient co-development within communities, so as to deliver results more cost-effectively, faster, and better than before – while also improving outcomes for customers.

A fourth factor is the growth in automation. This, too, is addressed in depth in this year's report. Even simply in the form of robotic process automation (RPA) and bots, automation can deliver significant benefits, so it is a disappointment that its adoption for testing purposes is not growing at the pace that was anticipated.

We believe intelligent automation will take cost benefits to even higher levels. We're already seeing scenarios in which testing is being used to increase revenues. For instance, AI platforms are being employed to see where users are struggling with apps, so testing can be applied more judiciously, and in production, to ascertain which changes deliver the greatest improvements. At Capgemini, we estimate that 20% of all testing will encompass artificial intelligence, and independent research

suggests that by as soon as 2020, it will form part of 40% of all software development.

The fifth and final factor worth mentioning that influences cost and efficiency is shift-right testing. This testing-in-production approach enables companies to implement updates sooner, search for and find defects quickly, and fix them while in operation. It's an increasingly common approach: in the short article included in this section, a quality assurance director at a large North American bank mentions its appeal in the financial services sector.

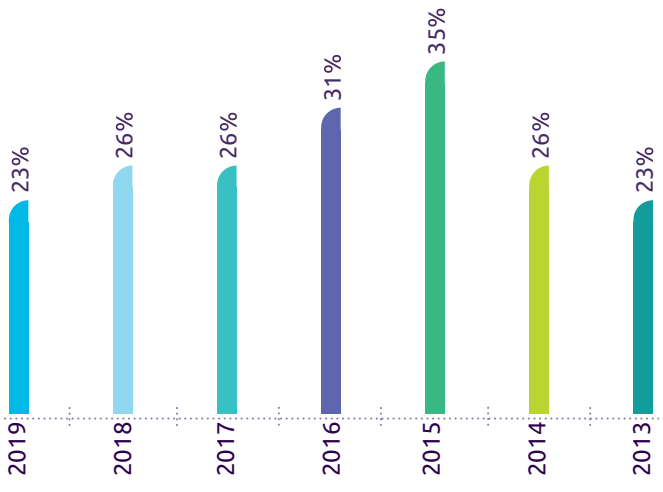
However, shift-right testing is not a replacement for shifting left; rather, it complements the shift to the left, allowing companies to build in continuous testing and continuous feedback loops that extend all the way out into production and back into development.

Current trends…

All these factors have a bearing on testing as a proportion of overall IT spend. This year's report shows the trend that began in 2015 is continuing. In that year, testing and QA accounted for over a third of IT budgets; those investments have since been paying off, to a point where this year, the figure has dropped to below a quarter (see Fig 14).

It is, however, worth noting that other factors are contributing to this trend. As we have seen earlier in this article, the new tools and techniques that are being introduced, in and of themselves, are proving to be more cost-effective. (Automation, in particular, can significantly improve ROI.)

Fig 14 Proportion of total IT budget allocated to QA and testing (including testing processes, tools, and resource costs)



In our view, overall IT budgets are unlikely to change significantly in the foreseeable future. A greater proportion of them may well be allocated to the implementation of AI and automation solutions, and also to TDM and TEM – but this will be in expectation of savings. We're already seeing organizations that are seeking or calculating break-even projections on potential AI and automation performance before they commit funds.

Within the testing and QA budget, we're also seeing a general downward trend in the proportion allocated to human resources. This figure stands at 26% of budget this year, against a high of 35% in 2014. The increase in automation may be a factor here – but conversely, this year's figure is up on two years ago, which may suggest the level and size of teams has grown in order to design and implement these new, automated routines.

All this might explain why, when asked to look ahead three years, our respondents envisage testing will command a lower proportion than ever of overall IT spend. In 2016, people expected that in 2019, testing would account for 40% of budget; this year, their forecast for 2022 is just 27%. Organizations are clearly investing in automation for several reasons, and one of them is long-term cost efficiency. Indeed, future investments in artificial intelligence are likely to result in further gains.

What's more, it is unclear if the testing budgets incorporate the management of test environments and test data, since in most organizations, these are still completely under the control and budgets of the testing team.

Also, with agile and DevOps models, it is still unclear how accurately budgets are being tracked for testing. While the objective research shows a downward trend in QA budgets, it is most likely that the real spend on testing could be about 3–5% higher.

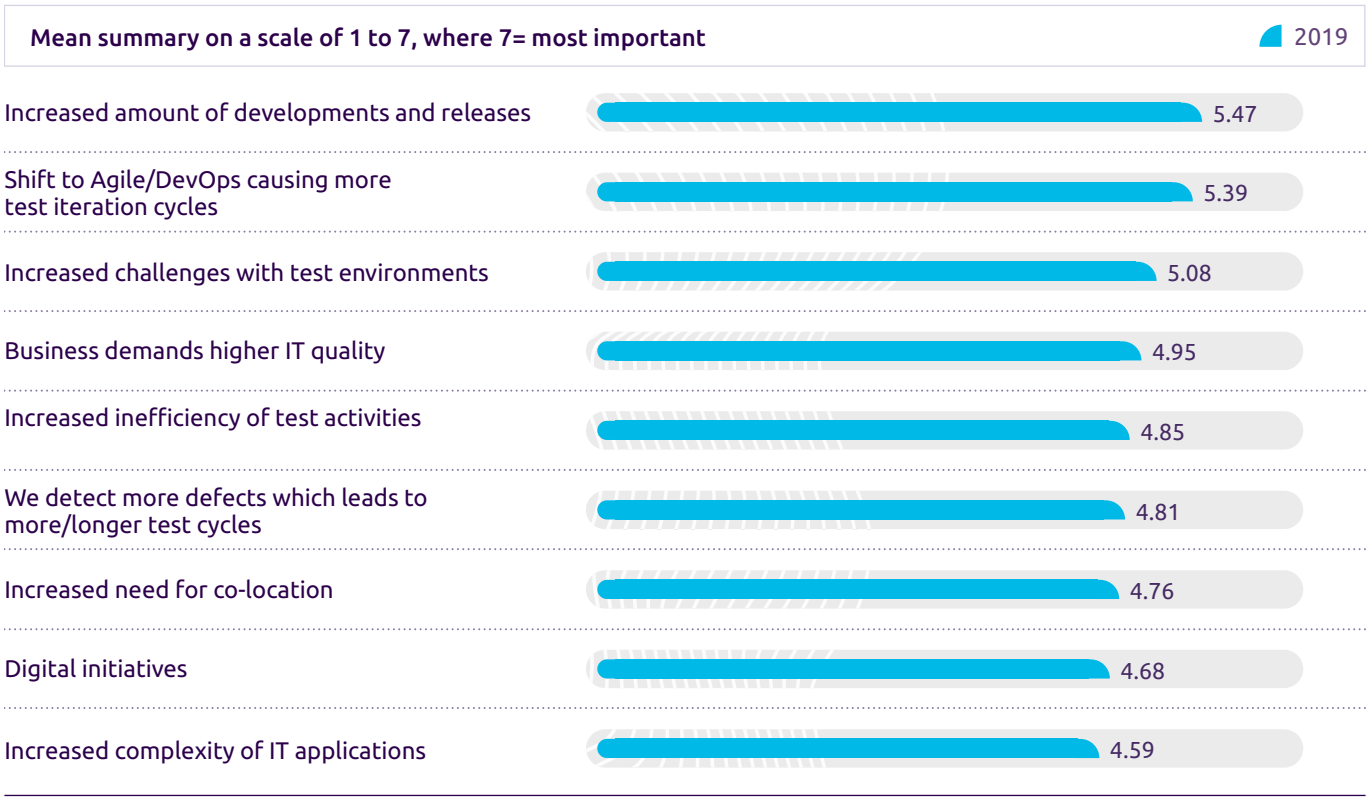
… and current pressures

Finally, it's worth considering a new question that was introduced in the World Quality Report this year. We presented our respondents with seven aspects of testing, and asked them to place them in the order in which they felt they have had an impact on the increase of QA and test budgets (see fig 15):

A significant amount of budgetary pressure is implicit in these numbers. What's especially interesting, in our view, is that quality is becoming less and less of a stand-alone matter. With business demand increasing for more releases, and at greater speed of delivery, we can expect quality to become ever more embedded directly into the development process.

It will be interesting to track this question in future reports, and to see what trends may develop. One thing is for certain – and that is that while the drive for higher quality at great efficiency may evolve, it won't be ending any time soon.

Fig 15 Factors having an impact on increase in QA and testing budget



LeaderSpeak:

Notes from quality assurance thought leaders

Director, Quality Assurance
North American bank

This year's report has seen continuing changes in the costs associated with quality assurance (QA). "Three years ago," says the QA director at the wealth management group of a major North American bank, "our focus was on cost reduction, and we achieved significant results. Costs can hurt infrastructure development and maintenance, and more besides. Now, however, our teams realize that cost-effectiveness may not also deliver the quality and speed of delivery that we want." This is why, he says, organizations are seeking to right-size their approach, and possibly to achieve this through a pure managed service delivery model. This means bringing together quality engineering (QE) and development teams to deliver work from offshore to achieve cost-effective results.

Testing costs

However, our interviewee says, it's the technology that's making the biggest difference. The increasing use of DevOps and AI will bring new levels of quality engineering to the development phase, reducing the emphasis on post-development testing. This, in turn, will change the cost structures, he says.

The bank's QA director explains how this is happening. Older technology stacks that are currently productive and generating profits in the Financial Services (FS) sector are increasingly being threatened by the new business models that emerging technologies make possible. This is obliging established organizations to follow suit, using not just DevOps and AI but also blockchain technology, supported by the testing workbench.

In the shorter term, investments in these technologies will lead to an increase in costs. Large, older systems with multiple lines of business had relatively low development and test costs; newer systems need more resources to understand and develop them, and they also need to reduce the complexity they've inherited, so as to create an entirely new and sustainable ecosystem. The technology will ultimately make things simpler, and costs will reduce; but also, organizations can use the opportunity it presents to consider changing their business model – for instance, working with an external services provider and with vendors. The QA team in this case is doing this successfully, and the rest of the bank is heading in this direction.

Skills evolution

Because of all this, skills requirements will change. The need for testing, coding, and maintenance will reduce – for instance, there will be fewer coders developing more intelligent code – and the testing workbench will absorb the role of testing teams, running quality checks, and evaluating new developments against a sample customer base before wider rollout.

The bank cites intelligent trading platforms as an example. If artificial intelligence is working properly, and is making right decisions, the company is in business. If it is making poor decisions, the company will lose out. Ideally, the bank's QA director says, tests need to be made actually in production. It's a big decision to make, but more than anything, logic and philosophy in AI will define its success. He points for illustration to differences between western and Asian cultures: in the west, people tend to seek one root cause for a problem, while it is the Asian (and in particular, the Indian) way to seek several causes through multiple cycles. For these practical reasons, from a testing perspective, he doesn't envisage much offline AI testing being conducted. It will rather be in practice.

A changing world

The QA director feels his team is setting the pace at his bank, and indeed among FS peers. The team is developing test workbenches using smart dashboards, QA bots with self-monitoring, and self-healing capabilities. In the old world of IT, current systems architectures will charge customers for any trading transaction; but in the new world, the customer can self-serve at no charge. With changes like these, there will be more, customer-driven business involvement in processes. Workbenches will be up and running, and testing will become a mere function. All of this, implemented with insight and specific to context, is helping the QA team to achieve new levels of efficiency, and the rest of the bank is noticing.

The new systems that emerge from these developments will, the QA director believes, be distributed. Centralized systems, he says, like many of the established platforms we see now in the FS sector, are susceptible to accretions and to the creation of siloes that, over time, become ever more of a burden to maintain. The challenge is how to test the decommissioning and breaking down of these siloes, and then assemble ecosystems in a new and more productive way. Digital transformation, of which automation is part, is key in this process, and will also reduce the need for testing. The pace of change is a challenge, but it's better to address it than to do nothing.

"I'm excited about our model," the bank's QA director says. "Genuinely excited. I wish I had another 20 years in this industry to see how it all pans out."

Sector Analysis

Automotive

The automotive industry is transitioning to new platforms – and the benefits are already being felt

Andy Howard
Vice President, Application Services
Capgemini

What is shaping the automotive sector right now? The answer is still CASE. Connected, autonomous, shared, electric vehicle development is well under way, and the pace shows no signs of slowing.

It is one of the most fundamental shifts in transportation since the development of the combustion engine, because it changes not only the nature of the vehicle, but the digital journey that supports it, the business model behind it, and indeed the society that surrounds it.

In business terms, CASE developments are causing disruptive change. Emerging technologies are creating partnerships across what might once have been boundaries, but are now complementary areas. New working models are emerging as a result, involving more players, and all this has implications not just for how software is designed and developed, but for how it is put through quality assurance (QA), tested, and secured as well. For example, when vehicles are to be shared, what are the data privacy implications – not just for cars, but in industry? In agriculture? In construction?

Here's another example of complexity and its implications. When vehicles are the result of an ever-more granular supply chain, how are components to be tracked, and at how many levels will Internet of Things (IoT)-based tracking need to work?

In short, it's a complicated and fast-moving picture, in which the responses from the sector on QA and test-related issues can be no more than a snapshot.

Industry drivers

This industry context is reflected in people's views of their IT strategy, and of what they deem to be important. Customer experience is at a high level, of course, and so too, is security – perhaps a little higher, in fact, than we would expect. Indeed, security issues are fairly prominent throughout this year's data set. This is possibly because the smarter that vehicles become, the more data they hold, and the more they give access to other data held elsewhere. Also, the broader supply chain can create issues; and indeed, 58% of automotive industry respondents – a significantly higher number than for the survey as a whole – say one of their greatest technical challenges in applications development is with security validation.

The greatest challenge automotive industry respondents face in testing their key applications is that they have insufficient time in which to test: this year, 43% report this to be the case. While this is an issue across all industry sectors, we suspect that in automotive, it is exacerbated by the fact that many companies are transitioning to new platforms while also being obliged to maintain their legacy systems. This bimodal IT, as it is sometimes termed, puts a squeeze on testing times, but also creates other testing challenges, including not having the right testing process or method, not having an in-house testing environment (36% in automotive say this, against an overall survey average of 32%), and not having the right level of test automation.

Moving forward

The automotive industry is, as noted, transitioning to new platforms, and there is much interest in DevOps. Our survey shows things are moving in that direction, and that testing in the DevOps environment occupies a significantly higher proportion of project and testing team effort than in other industries (30% versus 27%). It's proving a challenge, but it's top of mind for everyone to move away from siloed structures into new, faster, and more flexible development areas.

It's this keenness to progress that lies behind perceptions of skills gaps. When asked about the extent to which agile and DevOps change the skills needed from QA and test professionals, our total survey sample identifies deficiencies in test automation skills at 31%, and in test environment and test data skills at 27%. However, for the automotive industry, these figures are much higher, at 40% and 36%. Companies are clearly impatient to reach a point where they fully achieve the benefits they seek.

Artificial intelligence is also creating skills gaps. As in other sectors, the areas in which AI is creating the greatest need include software development engineering testing skills (S-DET), development and coding skills, and the understanding of how AI may affect business processes.

However, far and away the greatest difference is in the effect of AI on skills in non-functional testing areas. Among our survey respondents as a whole, the figure for whom this was an issue is 28% – but for automotive respondents, it is 49%. Non-functional tests apply to areas that include performance, which is of course a key issue in this industry, especially for autonomous vehicles. Another area covered is security, and, as we have seen, this is of growing significance across the industry.

Test automation

The automotive industry finds test automation highly beneficial. Around three-quarters of the sector's respondents report better reuse of test cases (76%), and better detection of defects (73%), against figures in the mid-fifties for survey respondents as a whole. It will be interesting to see how things develop in years to come; CASE automotive development is proceeding rapidly, and regulators aren't fully keeping up with it.

If there are benefits in test automation, there are also challenges. Several of them are factors of the pace of change, and of the bimodal IT problem; the industry is doing its best to catch up. The proliferation of automation tools is also clearly an issue. This may be because test groups in the automation industry tend to be in siloes, working on different projects, in conjunction with different external specialist partners, and making their own tool-buying decisions.

The bimodal IT issue also explains why testing and QA accounts for such a significant proportion of the total IT budget: a full 25%, against a survey-wide average of 23%. When you're living in two worlds, it's both difficult and critical to get things right, so you're always going to need to maintain that high spend. Indeed, 93% of respondents in the sector say that over the last three years, they had experienced an increase in proportional effort and cost spending on QA and test activities.

We believe automotive organizations are investing in the right people, in the right processes, and the right tools. They are preparing for the day when they need be bimodal no longer: when the transition from legacy systems is complete, and they can focus on sustaining levels of quality engineering that are in synch with the rapid developments taking place in their businesses.

The automotive industry is, in short, on the CASE.

Consumer products, retail, and distribution

The CPRD sector continues to lead the way in technology – and in QA and testing

Hitesh Naidu
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Capgemini

Technology changes everything. That's a given. But the market on which it has probably had the earliest and most profound effects is the sector covering consumer products, retail, and distribution (CPRD). Why? Because it's the most customer-driven market there can be. People bring their online behavior to work, whether that's in finance, energy, life sciences, automotive or elsewhere – and in every case, that online behavior is learned, and those experiences are set, by the time they spend in their omnichannel lives, browsing, filtering, comparing, judging, and deciding on their purchase decisions at home.

The Audience of One

Online retail is the great disaggregator. In the bricks-and-mortar world, products can be piled high and sold cheap; but online, the expectation is that order fulfillment will be individual, that purchases can be delivered, and that, yes, prices will still be low. Personalization is constantly being taken to new levels, placing increasing demands on the supply chain, as well as on manufacturing and marketing – and as a result, organizations have to find new and better ways to make sense of all the data they are creating. They need to reaggregate and analyze information about the Audience of the Many so they can better understand and satisfy the Audience of One. The development and test implications of all this are many. Scalability, robustness,

flexibility, security – all these functions are growing in scope, and in importance.

The increasing granularity of the market is perhaps why managed application services are growing and evolving – and also why we are increasingly seeing testing being conducted on an as-a-Service basis. At the same time, and as a result, the nature of testing is itself evolving. Several major consumer products companies are moving away from test as a discrete function, and towards its absorption into general IT development processes, especially in agile and DevOps contexts.

The customer imperative

The climate in, and the drivers of, this sector explain much of what we see in this year's survey. The stated objectives of quality assurance (QA) and testing are, as we would expect, all at or above average. In retail, business growth is tied especially closely to end-user satisfaction, and the detection of software defects – any one of which could lose impatient customers – score highly, too. Indeed, the fact that the sector is above almost every stated objective cannot be a surprise.

For the same reason, elsewhere in the survey, respondents tell us that the two most important aspects of their overall IT strategy are enhancing security and customer experience. Why is security so high? Because, here more than in any other market, the surface area over which businesses touch their customers is so extensive. There is greater exposure, and it's growing.

Testing times

The challenges CPRD companies face both in developing and testing their key applications are likewise to be expected. In development, the two areas in which the sector differs considerably from the average are, first, in the number of people saying the testing process is too slow (59%, against an overall average of 48%); and second, in the number of those saying they experience a lack of proper requirements (42% against an average of 34%). In an industry as fast-moving as retail, testing will always be playing catch-up; and the lack of requirements may perhaps also be explained by the speed of product development. When new items need to go to market fast, it may well be that the IT development brief that accompanies them isn't always clear.

In testing, we also see the lack of time feature prominently, with just over half of CPRD respondents (51%) agreeing it is a challenge. The lack of appropriate expertise is also an issue, with 35% of people mentioning it.

The market pressures of the industry are reflected in several ways in this year's figures. For instance, we see adoption of agile methodologies advancing at a faster pace than in other sectors, and CPRD companies are also significantly ahead in planned or current AI and machine-learning (ML) projects. As many as 64% of respondents report ML projects are in place on internal CPRD processes, while 60% say AI projects are in place on customer projects. The industry clearly wants to maintain momentum in this respect. Demands for enhanced QA and testing skills prompted by AI are higher than average in almost every category – for example, in development and coding skills, in data science skills, and in the understanding of the implications of AI for business processes.

With test automation, CPRD organizations are addressing the same challenges as others. For instance, almost two-thirds of them (64%) say their attempts to automate are hampered by the fact their applications change too much with every release. However, they do feel they are accruing substantial, business-led benefits. They are saving time and money; it is easier and quicker for them to make changes; and they are able both to detect defects and to release new levels of functionality faster. (We expected to see positive feedback on the reuse of test cases, but the figure seems high to us.)

Pressure to change

Indeed, the importance of achieving such benefits in this industry can't be overstated. The increasingly personal service demanded by consumers has accelerated the need for smarter, more function-rich apps, and has also increased the number of transactions. At the same time, security needs are increasing.

Perhaps most importantly of all, all these factors are creating pressure on consumer and retail businesses to change or extend their business models. The variety customers seek isn't only in product type, but in touch-points (online and in store); in product quantity (single and multi-buy); and in methods, places, and times of delivery. It means retailers of online and bricks-and-mortar origins alike are having to reinvent themselves in the mold of the big web-based shopping platforms, with the marketing, the transaction functionality, and the supply chains to match.

Dependable quality assurance and testing have always been of high importance in this sector – but we are currently witnessing times when they will be absolutely, make-or-break, crucial.

Energy and utilities

The energy and utilities industries are facing macro-economic, IT, and QA-specific challenges – and they are showing determination

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Energy, utilities, and chemicals (EUC) are an area in which geopolitics and macroeconomics can wield a great deal of influence, not just on the industries as a whole, but specifically in terms of their ramifications for technology in general, and for testing and quality assurance (QA) in particular. So, before we examine this year's survey data and consider what it tells us, it's worth looking at the big picture.

A world view

There has been a significant degree of instability and uncertainty in relation to several of the world's oil- and gas-producing countries, with economic upheavals, sanctions, and threats of trade wars. But that said, oil and gas prices this year have largely been stable, with oil trading in the $50–$60 a barrel range, enabling companies to turn decent margins, which they can then invest. There is a slowdown in demand in some major economies, including China and India, and this, coupled with high shale gas production levels in the US, means that there is some oversupply in the system at the moment.

The carbon footprint issue is a significant factor in Europe, and it's growing in the US and elsewhere, too, which means we're seeing greater investment in renewable energy sources. Interestingly, much of this new money is coming from non-traditional market players, including major technology companies, so it will be interesting to see the role that traditional energy players continue to evolve for themselves over time. We're also starting to see greater investment in

smart storage and batteries, although people are still figuring out how best to monetize this area.

Business pressures are growing. Upstream and downstream activities are both feeling the pinch on costs, which means increasing cashflow is important. Some consolidation is taking place in the sector, necessitating some post-M&A systems integration; the customer experience is growing in importance, creating a demand for customer information systems that can deliver a more retail-like experience; and, as we shall see in a moment, digital transformation is precipitating a transition to the cloud, as well as growth in artificial intelligence and analytics, although all of these are still pretty much still at proof-of-concept stage for many. Finally, as far as this general view is concerned, we see, first, cybersecurity occupying ever-greater levels of attention (such is the industry's sensitivity to threats); and second, the rapid and widespread adoption of the internet of things (IoT), at every stage from exploration through processing to delivery.

Challenges and skills gaps

Turning to this year's data, we find that, while the momentum is indeed behind a move to agile developments, there are nonetheless challenges to overcome. Among their principal concerns, respondents in the EUC space report the lack of sufficient test environments and test data, and an inability to apply test automation at appropriate levels. To a greater extent than for other respondents in our survey, they also declare a lack of professional test expertise in their agile teams.

This skills need is explored in more detail in a later question. Agile and DevOps do indeed change the skills needed in test automation, and also in test environment and test data skills – but we also see an increased need for knowledge of business processes, and an especially increased requirement for security skills. Energy, utilities and chemicals businesses safeguard highly critical infrastructure, and in a fast-moving climate of risk, robust protection levels are absolutely imperative.

Challenges in AI and test automation

It is heartening to see the extent to which artificial intelligence developments are under way in this sector. Current projects are in place in a range of areas, including external processes, customer processes, and quality assurance. In all these instances, the EUC sector is significantly ahead of responses from other markets in our survey.

However, future AI plans are unclear. The activity rated highest by EUC respondents with respect to such plans is the establishment of AI trials and proofs of concept. We are not, in other words, yet seeing solutions being implemented at scale.

One reason for this may be, once again, the perennial problem of available skills. Our survey responses indicate that the greatest QA and testing needs generated by AI developments in the EUC sector are in software development engineer testing (S-DET) skills, in the understanding of the implications of AI for business processes, in development and coding skills, and in data science skills. It is no surprise to find that in almost all these cases, the need in EUC is greater than elsewhere.

In test automation, it is good to see EUC companies achieving benefits in terms of control, cost, time, security, and more; but in terms of moving the agenda forward, the challenges they say they face are interesting. At higher levels of automation, the greatest issue the sector says it has to tackle is that flaws in test environments and in test data provisioning are causing automated test sets to fail. Another issue is with teams who say they don't have enough time to create automated test cases. It seems to us that this is a surprisingly circular argument: it's rather like the lumberjack who gets behind with felling trees because his saws are blunt, and who says that as a result, he doesn't have time to stop and sharpen one. A solution to this conundrum might be to continue with the task, while someone else, in the shape of an external services provider, performs the equivalent of saw-sharpening by setting up test cases and test libraries that will enable time-saving automation to happen.

It's also good to see the EUC industries so keen to adopt test environments and test data management, in spite of the challenges that need to be overcome. Although it's not plain from this year's survey data, we're seeing a growing appetite for testing in containerized test environments such as Docker – and it's interesting to see that hardly anyone at all says they are not doing any kind of cloud-based testing.

Facing the future

Finally, a look at costs. Current and planned budgets for energy, utilities, and chemicals businesses are broadly in line with those of organizations in other sectors, but the issues that are deemed to have had an impact on QA and test budgets are intriguing. Our respondents note an increased number of developments and releases; increased challenges with test environments (as we have seen); and the fact that the shift to agile and DevOps is causing more test iteration cycles. An increased need for co-location is also mentioned. This is a particular issue in this sector. We see it especially in global agile programs, which can be difficult to implement across broad geographies.

Taking stock, then. The energy, utilities, and chemicals markets are more subject than most to the tides of global politics and macroeconomics – but equally, they are as susceptible as any other industry to developments in IT in general, and to the evolution of QA and testing particular. There is no reason to think businesses in this sector won't continue to tackle and overcome the challenges they face with characteristic determination – and yes, with their habitual energy, too.

Financial services

This year's survey shows financial services organizations are looking for a new template in almost every area of testing and quality assurance

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The financial services sector has a reputation for blazing the trail in technology, so before we look at this year's survey data, let's look at the latest trends driving this segment.

This is an industry that has always been subject to rigorous and ever-changing regulations. Regardless of the changes brought in by these regulations, financial services organizations need to continuously drive effectiveness and efficiency across their risk and compliance programs to meet applicable laws, regulations, and supervisory expectations. This, in turn, puts greater demand on testing and quality assurance (QA) to achieve speed, efficiency, and the right quality. Hence, we see greater thrust and worry emerging from our respondents in the area of talent availability, drive automation and ability to adopt right technology and processes.

As a result, the skills requirement for testing professionals is undergoing a massive shift. From largely functionally knowledgeable testers, the demand has moved to having a good blend of technical and domain skills. The need is for testers who can fit in multi-disciplined teams seamlessly.

We're also seeing acceleration towards adoption of advances in analytics, machine learning, and artificial intelligence in testing domains. Businesses are adopting a "test smart" rather than a "test all" approach.

The other aspect is the adoption of agile and DevOps. While the benefits of these methodologies are attractive, some organizations need to make this transition while accommodating their legacy technology landscape. This, too, has team implications; those multi-skilled people need to be able to cover established as well as emerging tech needs.

The final part of this scene-setter is structural. We're increasingly witnessing a change in shape to the way testing teams are being organized. Testing centers of excellence are becoming decentralized and federated into different lines of business. The silos between development, ops, and testing are breaking down. At the same time, there is a need to drive efficiency through standardized sets of tools, processes, and shared services such as test environments, test data, security testing, and performance testing. A new blueprint seems to be emerging, but it is still far from mature.

Strategic drivers

Our detailed analysis begins with consideration of overall testing and QA objectives, and also of the key drivers for IT strategy.

The financial services sector this year places more emphasis than our survey respondents as a whole on every suggested testing and QA objective, including the detection of software defects before go-live, increased quality and security awareness among all disciplines in the sector, and the implementation of quality and security checks earlier in the lifecycle. We note that this year's top objective is contribution to business growth and business outcomes. Last year, it was ensuring end-user satisfaction, which still achieves a high score this year.

Key drivers for IT strategy are largely in line with expectations. Security, customer experience, and software quality are all highly important, and cost optimization remains an important issue. In financial services, testing and QA are often regarded as a regrettable necessity – people don't like spending the money.

Two figures here strike us as a little odd. Cloud transformation seems a little high: rightly or wrongly, it makes people in financial services apprehensive, for security reasons. And implementing agile or DevOps seems a little low. As we've noted, out in the field, we've seen a lot of energy invested in this area.

In light of this, the challenges people see in applying testing to agile development make for interesting reading. One of the greatest departures from the survey-wide average is, as we might expect, for a lack of professional test expertise in agile teams – a financial services response of 49%, against a survey average of 43%. Issues with test automation (to which we shall return shortly) also feature strongly, and the greatest challenge of all is the lack of appropriate test environments and data, mentioned by 59% of financial services respondents. It's the sensitivity of data in this sector that make this such a significant issue.

Getting smart – and automating

We're not yet seeing as much activity in artificial intelligence (AI) and machine learning as this year's numbers suggest – the claims for the number of projects currently in place seem quite high to us – but it's certainly a major part of people's plans. Financial services respondents tell us almost a quarter (24%) of their total IT budget is earmarked for investment in AI projects, against a survey-wide average of 21%. We believe businesses are building their expertise. Banks, for instance, are increasingly sifting their data so they can better understand their customers, while in insurance, AI can be used to improve demographic analysis and increase engagement.

The issues with test automation mentioned above are articulated clearly in the survey. The high response given for the moving target of applications releases is no surprise at all, and indeed, the scale of the challenges expressed by our respondents is fairly predictable. The issue with manual steps within test processes, for which there is a significant departure from the survey average, may be because of the obligations of dealing with legacy systems, as mentioned earlier.

The types of testing performed by the financial services sector in a cloud-based test environment are broadly on a par with our overall survey average, although we believe this parity is skewed by the relatively high number of people in the industry using such environments simply to perform functional tests of cloud services. It's a further sign, perhaps, that a broader use of cloud-based test environments is being held back by concerns about security.

And yes, those security concerns are indeed high. Figures for every aspect of a secure development strategy are significantly above the norm:

- Security requirement identification, elicitation and evaluation
- Static and dynamic code scan
- Secure Code review
- Toll gates to ensure secure code deployment as part of a DevOps implementation.

A new business template

In a sense, though, the importance of security in the financial services sector is pretty much a given. The main challenges in the years to come will be in meeting skills needs, and in implementing test automation in a way that can improve quality and productivity at the same time.

In order to address these challenges, financial services organizations are looking for a new template for just about every area of testing and quality assurance. They are exploring new approaches to development; to their operations and testing structure; to the tools they organize and employ; and to the people they hire, and the teams they build.

This has implications not just for the businesses in the sector, but for the service providers that support them. Things are going to get busier – but, with effort and luck, they are also going to get more rewarding.

Healthcare and Life Sciences

The healthcare and life sciences sector faces demanding and sometimes unique challenges – and it's raising its game in QA and testing

Azfar Mallick
Vice President, Capgemini Group

The context in which the healthcare and life sciences sectors run their quality assurance (QA) and testing functions is conditioned by several trends, some of which are specific to these industries.

The trends …

The first of these is pricing. Every business needs to be competitive, and every business also needs to watch its costs – but this sector is subject to much greater scrutiny in these areas, and in particular on what it charges for what may be life-saving products and treatments. Healthcare and life sciences organizations therefore need to be particularly mindful of how their pricing is perceived. This may lead to compromises on margins, but it can't result in any compromises on quality. That is simply not an option.

A further trend is speed to market. In the last year or two, the pressure to deliver faster has led to several major mergers and acquisitions. These, in turn, have caused major disruption in the industry. Test functions and test tool portfolios need to be consolidated and, if possible, streamlined, which is why companies are increasingly scanning business cases and assessing whether automation techniques can help. Ultimately, it's a leadership initiative: those companies that choose to invest here are, we feel, more likely to succeed. (We'll return to automation a little later.)

A third trend is a cultural one: the world is seeing a shift from what we might call a "treatment by prescription" model to something that is more holistic, and less specific to the condition presented by the patient. Healthcare and life sciences organizations are expected to be moving away from, say, targeted medicines, and more towards whole health and wellness.

A fourth and, for now, final industry trend is an increase in front-line cognitive and artificial intelligence solutions. We're seeing digital surgery; we're seeing cognitive diagnostics of volume medical data such as MRI scans or mammograms; we're seeing IoT-enabled (internet of things) medical instruments; we're seeing chips in pills that, upon ingestion, can measure the absorption of the medication in which they are embedded.

… and their implications

What impact are these trends having on quality assurance (QA) and testing?

Implicit in them is a need for more technology and for more tech skills:

- IT needs to test against more and broader criteria, including user behavior testing, and user consumption testing.
- This, in turn, means new testing frameworks are required.
- Evolving technologies need to be accommodated. For example, intelligent platforms are appearing that can help teams coordinate, manage, implement, and automate tests, and accelerate time to market.
- New skillsets are needed, not just for these developing and emerging technologies, but for understanding and responding to user needs and actions.

The cost trends and market realignments we've seen are making a different kind of impact. The way test regimes are conducted obviously make a difference to margins in terms of efficiency; but, more than this, these industry shifts are helping to shape new business models. The need to streamline and optimize is precipitating moves offshore to third-party organizations that can provide digital services on a managed services basis – especially when those providers can demonstrate current knowledge of AI, machine learning, and cognitive processing.

Implications such as these are reflected in the feedback we see in this year's survey. For healthcare and life sciences respondents, the contribution to business growth and business outcomes is the most important objective when it comes to testing and QA. On the one hand, quality helps to sustain corporate image; on the other, achieving quality efficiently helps to achieve expectations on cost. Also for reasons of market trust, as well as to meet regulatory requirements, the emphasis placed in the industry on enhancing security as an important aspect of IT strategy is to be expected. Healthcare and life sciences organizations are among the sectors obliged to take cyber-attacks most seriously. This is why challenges with security validation are much higher in this industry than across our survey as a whole – 66% in this sector, against 52% in the whole cohort.

Test automation in healthcare and life sciences

Further significant challenges in these industries are the lack of end-to-end automation, from build through to deployment; and the lack of sufficient time in which to test (no other industry sector this year scored this challenge higher).

This is why, here as much as anywhere in business, the need for test automation is so pressing. The sector is behind financial services on test automation, but it's catching up fast. In particular, it's needed for regulatory testing, so as to reduce cycle times. Also, there is a move towards handling risk-based testing in this way, but most organizations in the sector aren't quite there yet.

Healthcare and life sciences organizations share the challenges of automation with businesses in other sectors, but to different degrees. While changes to applications are less of a problem than in other industries, they remain the greatest issue. In addition, we see challenges with testing environments, and with the availability of appropriate skills and tools – this last one, especially. People are keen to leave manual processes behind, and to move on.

Agile, DevOps, and AI

Agile has been a mainstream development approach in healthcare and life sciences for the last two or three years, so it's a little surprising for us to note that its mean score on a par with other industries. We are yet to see its benefits: agile hasn't yet transformed business processes or outcomes. Elsewhere in our survey, we learn that the greatest challenge in the industry to the application of agile development is the inability to apply test automation at appropriate levels. The lack of QA guidelines is also cited.

DevOps is less mature in this sector, but it is of great interest: businesses are keen to capitalize on its benefits, but they realize that by breaking down siloes, it may create organizational challenges.

Artificial intelligence projects are in development in the sector, or are planned over the coming year, but it is a significant surprise to note that this is far less the case in QA processes than for other industries: the figure polled for these industries is 29%, against a total average of 42%. That said, overall investment in AI is slightly higher than average, and we're seeing much discussion about its introduction.

In summary, the healthcare and life sciences sector is responding to the recent trends it has experienced with new levels of determination. Funding allocations for QA and testing may still be running at around 15%–20% of IT budgets, which is lower than in other industries, but the commitment to investment in intelligent automation and in smart QA is growing. As time passes, we're going to be seeing greater use of AI, machine learning and natural language processing (NLP) – and the aim will be to meet the highly demanding and, in some cases, unique business challenges of these industries.

High-Tech

The high-tech sector is at the forefront of adoption of several new techniques in QA and testing

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It's reasonable to expect high-tech industries to blaze trails when it comes to the development and adoption of new technology, testing and quality assurance (QA) processes within their own businesses. Indeed, many of them are keen to take innovations to the proof-of-concept (PoC) stage. For example, in this survey, 28% of respondents from this sector say that their most important activity in AI is to put trials and PoCs in place.

Business-minded

However, in our experience, they are no faster than other sectors when it comes to actual rollout. This is probably because they, too, are still bound by the same commercial principles as everyone else. Over the last year, we've seen attitudes to investment in technology become much more pragmatic. There is no open checkbook: management is keener now to see demonstrations of potential business impact before it makes commitments. The IT teams need to justify all that capex.

This is reflected in this year's survey, where the continuing importance of quality as a test objective has been joined – in the top spot, in fact – by "contribution to business growth and business outcomes," cited by more than 45% of respondents.

Factors driving IT strategy in general are interesting. The emphasis on security is to be expected. Because of the nature of their business and their many interactions with their customers and end users, all high-tech organizations tend to be prone to cyber-attacks.

Almost 40% of the respondents still rate "enhance customer experience" as the most important aspect of their IT strategy,

with a similar figure given for the high quality of software solutions. Indeed, elsewhere in the survey we see that 'ensure end-user satisfaction' has been rated as the top objective within testing and quality assurance by 69% of respondents.

The increased business-mindedness of the IT function in this sector is particularly pertinent: figures for the 'cost optimization of IT' are significantly higher for this industry than for our respondents as a whole. Companies are clearly trying to optimize the total cost of ownership (TCO) of their technology investments while at the same time improving not just their interactions with customers, but their business impact. These are substantial challenges.

IT challenges

Test automation is starting to mature in the high-tech sector, but the industry is lacking in end-to-end testing, of which automation forms an integral part. This is the biggest challenge by far in applications development for all organizations, and for high-tech businesses in particular, it's much higher still. This was also the case in 2018, and it's not a surprise. With the industry focusing on development of connected products that are connected across both the operational technology (OT) world and the IT world, it is always a challenge to perform end-to-end automation across the technology stack, and the multiple layers in the stack make it harder still. The impact of IoT, and more and more high-tech companies developing products to fit into the fragmented IoT ecosystem, is adding to the complexity in setting up end-to-end automation.

Respondents in the industry were also asked about their challenges specifically in testing their key applications. "Not having enough time to test" is higher than for any other sector, and has indeed been the industry's top challenge for the last couple of years. In this regard, it's worth noting that the concept of "evergreen IT" is becoming very prominent in this sector, because people are looking at close-to-zero downtime for their IT and OT assets. They are also considering concepts such as over-the-air updates for their OT assets; and further, they are looking at continuous deployment for their IT assets. All of this puts a lot of pressure on the testing organization to be very efficient, because even if higher proportions of tests are automated, the challenge of sufficient time in which to test will remain.

This is why we have seen organizations seeking to apply analytics and AI to help them improve their test selection and prioritization strategy, identify the tests that matter, and identify the tests that need to be executed for every change. Indeed, when our respondents were asked to rate the importance of various smart QA options, the most popular for high-tech businesses was the use of smart analytics to decide on areas of test focus.

Getting smart

As high-tech products become smarter, they are also becoming more sophisticated. More product features are being added, adding to time pressures, and as a result, identifying the right tests to execute is always a challenge. High-tech companies increasingly seek to apply analytics and AI to help them in test selection and prioritization, and to identify riskier areas to test.

Figures for general approaches to testing in the high-tech industry are interesting. The difference between figures for waterfall testing and for agile and DevOps testing are not that great. What it does show is that the boundaries between development and testing are blurring within the agile and DevOps teams, and that the traditional approaches of independent testing or centralized testing are also not being followed. This shows that there is a very thin line between what is regarded as pure testing activities, and the activities a developer would traditionally do. As a result, the new role of the software development engineer in test (SDET) is gaining in prominence. In this regard, it's important to note that 31% of the respondents in this sector feel their test engineers need to have data analytics skills and test case design skills.

We also asked where test automation is heading. As noted in the introduction to this article, we can see that the high-tech sector is at the forefront of adoption of new automation techniques. We have seen the adoption of robotics automation specifically by the aerospace and defense sector, to perform a high level of system testing activities on real products that have electronic, mechanical and software components. Given that the respondents to this survey are also participants from the aerospace industry, it is not a surprise that the uptake for robotics automation is much higher than other sectors.

In conclusion, it's worth noting that that our survey of the high-tech sector has even greater depth and breadth this year. As usual, the cohort of people we have consulted is broad, geographically and also by company size – from a thousand employees to 10,000 and above. This year, however, the usual job categories, including CIO, IT director, and QA/testing manager, have been joined for the first time by people holding the title of VP/director of R&D.

It means we have an even better idea not just of how things currently stand via-à-vis QA and testing in these industries – we also have even greater insight into where they're heading. And, given that high-tech businesses so often blaze the trail, this is knowledge worth having.

Government and public sector

Public sector organizations vary worldwide, but they all need to address the same trends in QA and testing

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Setting the scene for the public sector is not quite the same as for other verticals. In, say, manufacturing or consumer products, retail and distribution (CPRD), there may be some local variations, but fundamental commercial principles mostly apply. By contrast, the public sector varies significantly from one country to another. The architecture of government, at national, regional, and local levels, is different. Political and social objectives are also different, and so, too, are funding priorities.

What doesn't change are the stated obligations each public sector organization has towards the citizens it serves, which is why ensuring the efficacy of the enabling technology is so important.

This year, the respondents from the public sector and government constituted 15% of our survey total, making them second only to financial services in terms of sample size. More than 90% of our respondents in this sector were CIOs, QA/testing managers, IT directors, VPs of Applications, or CMOs/CDOs.

Identifiable trends

Because of the nature of the public sector, some trends may be specific to individual countries. For instance, in the UK last year, we witnessed a general move away from services. This year, while in-house testing is still common, we are seeing Testing-as-a-Service regaining in popularity – possibly as a result of changes in local tax laws, and the increasing challenge this represents.

There are other variations. Public sector organizations in some countries, such as the UK and France, like to hire in-country service providers, while their peers in other countries are more open to the notion of offshoring.

Similarly, European public sector organizations seem to be more committed to agile and DevOps developments than their peers elsewhere. They are also increasingly switching from time-and-materials frameworks to fixed-price solution models for critical projects – something that, in DevOps in particular, can be quite a challenge.

Objectives and challenges

Testing and quality assurance (QA) objectives in the public sector are broadly in line with the survey as a whole. Alignment with business growth remains the priority; the detection of software defects before go-live is important; and there is a significant focus on security awareness and, indeed, on security in general, across all aspects of the QA cycle.

We see many of these public sector trends extended into IT strategy as a whole. Customer experience, which is closely associated with business growth, remains of high importance, and so does security. The high quality of software solutions is another major driver – which is why, as we'll see shortly, agile and DevOps developments are playing such a key role in delivering better, faster, and more cost-effective solutions.

Respondents were also asked about the challenges they face in applications development. The public sector is in line with general trends, in identifying as key a lack of end-to-end automation from build to deployment. It's true that for many such organizations, test automation is still in its early stages, partly because in some instances, public sector bodies are working in a legacy context. Nonetheless, we see automation growing fast.

Security validation is a particular challenge in public sector circles, for reasons of public accountability; and, although figures for the sector are lower than average, the slowness of testing processes is cited as significant. Agile methodologies are being used to address this.

The most distinct difference we see between the public sector and other verticals is the high score given to the inability to test integrations at an early stage. In some countries, where the culture is as much as possible to keep things in house, this can be a struggle. It is, of course, also a factor in end-to-end issues: one reason public sector organizations have difficulty with integration is that the multiplicity of tools they own and use means there isn't always a clear tool strategy. Another is that agile projects can be hampered by attempts at integration in larger processes.

As far as challenges specifically in testing are concerned, we see the usual suspects emerge in our survey. Easily the greatest problem, for almost half of all respondents in the sector (49%), was "not enough time to test." The pace of testing is indeed faster. In our view, this is not just because the workload is growing, but also because of the way processes are organized, and because applications are changing too much with every release (almost three-quarters of public sector respondents say this is a particular challenge for them in automating tests).

Agile, DevOps, and skills

As in other verticals, in the public sector, we see agile and DevOps being employed in attempts to optimize costs and also system performance. While coping with legacy systems can make this a challenge, we nonetheless see these approaches driving change in individual countries, especially where workloads are volatile. For example, in the UK, Brexit uncertainties are leading to unpredictability as far as anticipated data volumes are concerned in some key application areas. Other agile and DevOps challenges highlighted by this sector are those we would expect:

- Lack of appropriate test environment and data, at 57%
- Inability to apply test automation at appropriate levels, at 47%
- Lack of professional test expertise in agile teams, at 49%.

On this last point, we see respondents in the sector telling us of the extent to which agile and DevOps are changing the skills needed in QA and testing. For every area of testing cited, at least a quarter of respondents said that skills were lacking. If anything, we regard this figure as low: the fairly high number of people who declared themselves happy with the status quo on skills is somewhat surprising.

The growing number of areas in which skills are needed is daunting. Test automation skills, performance engineering skills, test case design skills, collaboration skills, test environment and test data skills, knowledge of business processes – all these and more are on the wishlist, and finding people who tick all these boxes is unrealistic, especially when we also acknowledge the tension between broad generalization and high specificity that they represent.

It's been a challenge for the public sector to keep pace with developments in technology, and also with the evolution of the testing tools and frameworks necessary for successful implementations. Will organizations catch up? Will they even get ahead? The answer, to a large extent, will depend on the culture, budgets, and attitudes of the administration being served.

Telecoms, media & entertainment

The telecoms, media and entertainment industries continue to be fast-moving and competitive – and the pressure is on QA and testing to deliver

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It's an interesting time in telecommunications, media and entertainment (TME) – but then again, in industries as fast moving as these, it's likely that this will always be the case.

Telco trends …

To take telecommunications first: it's a highly competitive, consumer-driven market, in which it is difficult to get new tariffs, products, and services to market quickly. Companies in this industry have complicated estates, partly because of the breadth of their systems, and partly because it's a world of mergers and acquisitions (M&A), in which different infrastructures are brought together. Complexity is, in short, an ongoing challenge.

Another factor is that the advent of 5G will deliver new capabilities for telecommunications organizations because of the increased capacity and low latency that it offers. This will enable new technologies to be run over mobile networks, which telecoms businesses will exploit by creating new offerings, mostly in the b2b space – driverless cars, for example.

This will create a new quality assurance (QA) and testing dynamic. All these new use cases will need to be validated end to end. How so? Because the increase of internet of things (IoT) developments implicit in 5G has implications not just for IT applications, but also for the physical devices themselves. For example, it's not just the app managing the traffic light that needs to be tested: it's also the traffic light sensor itself.

Over the last year, we've also been witnessing a change of operating model. This is largely an attempt to reduce time to market, and to move more operations to the cloud. Waterfall is well established, but there are more agile and DevOps developments now, and much more interest in test automation, because of the speed to market they all offer, especially in a market context in which the risks of regulatory issues and of damage to reputation from faults and downtime are particularly high.

Another significant challenge is the need for test environments. Application estates are complicated, and highly integrated test environments are expensive to build and maintain; so the move to the cloud will allow telecoms businesses to achieve real benefits as they adopt cloud test environments.

Telcos are also changing their operating models and embracing design thinking. This is driving a move away from traditional testing models, with centers of excellence for key services that enable them to explore these new approaches. As we shall see in the survey data in a moment, the big issues are the availability of time in which to test, and the consequent need for test automation. Delays and quality issues together will have an impact on user satisfaction and on security – and, of course, also on growth.

… and trends in media and entertainment

Many of these drivers also apply in the media and entertainment industry. Once again, time to market is crucial; and once again, the complexity of the market is a major factor. This complexity manifests itself not just in M&A activity, but in customer-driven developments in the range of available viewing options – more content, available at any time, on any device, and in different transactional packages, including, rent, buy, and subscription.

All of these trends have a bearing on the development of products and services, and hence on QA and testing. Standards need to be maintained, and even enhanced – and, at the same time, companies still need to be swift to market, and still thinking ahead, positioning themselves to obtain great insight from expertly-interpreted, high-quality data. This is why test automation is continuing to increase in performance – and why the challenges in implementing it mostly have speed and complexity as underlying causes.

Customer-driven trends

As a proportion of our total survey cohort this year, the TME sector was third, with only the financial services and public sectors greater in size. Almost two-thirds of TME people interviewed (65%) were IT directors, QA/testing managers, or CIOs.

Among these people, the main objectives of QA and testing are consistent with the drivers outlined above. They are: contribution to business growth and business outcomes, ensuring end-user satisfaction, and protection of the corporate image and branding. Telecoms, media, and entertainment organizations alike all need to build their business through increased subscriptions, and to sustain that business by providing outstanding customer experience.

Data accuracy is particularly important in this market, and especially in media and entertainment. Understanding consumer behavior is vital, so anything that helps to identify the end customer through micro-segmentation is very relevant for content companies.

Areas we would have expected to feature more prominently among QA and testing objectives are those associated with security. Poor security can quickly impact customer experience and hence damage the business – and indeed, elsewhere in the survey, enhancing security is deemed by TME respondents to be the most important aspect of their IT strategy, so there is some inconsistency here.

Another curiosity is the response when people were asked about the technical challenges they currently face in applications development. The highest answer for TME respondents is the lack of end-to-end automation, from build to deployment – but compared to the average for the survey cohort as a whole, the figure is surprisingly low, especially when, counter-intuitively, almost as many people say testing processes are too slow.

Planning and demand management are of especial importance in telecoms, media and entertainment, and this is likely to be a significant factor in why more than half of respondents in these industries (51%) say they don't have enough time to test.

Agile and DevOps in TME

We have already noted the significance in this sector of IoT, especially in telecommunications, and 41% of TME respondents say they have a fairly mature IoT test strategy – a percentage point down on last year, and behind automotive, which this year comes in at 45% against this criterion. More significant, perhaps, is the progress being made in agile and DevOps developments. Project and team efforts in these areas are ahead of the survey average in both these areas. This is likely to be because of the complexity and convergence in the market, the speed of its development, and the expectations of its customers, all of which we have noted earlier in this article.

These same drivers are reflected in the challenges TME businesses face in testing agile developments. The inability to apply test automation at appropriate levels was cited by 60% of respondents in this sector – easily the greatest challenge they mention, and a full ten percentage points ahead of the overall survey average. These are industries in which the landscape is continuously changing, and in which the customer offer is constantly being reinvented, so it is clearly difficult for test automation processes to keep up.

This is why new or enhanced skills are in demand. Test automation skills are perceived as lacking far more in the TME sector than for the survey cohort as a whole. There is a significant need for data analytics skills, too. In media and entertainment, there is an especial need for data scientists, so tests can be developed that enable companies to segment their offer to customers and to advertisers alike.

Fast track to the future

The current state of this market can perhaps best be understood by considering the factors that have a bearing on the increase of QA and test budgets. Here, once again, we can detect the pressures of competitiveness, of complexity of offer, of customer demand, of the constantly changing shape of the market and its players, and of the regular arrival of new technologies – and we can see how they affect budgets more than in other industries in almost every case.

Businesses in these industries are set for the next few years to continue a rollercoaster ride. Daunting? Yes. Ups and downs? Certainly. But fast-paced, exciting, and exhilarating? Yes, those, too. This is a market worth watching.

About the study

World Quality Report 2019-20

The World Quality Report 2019-20 is based on research findings from 1,725 interviews carried out during May and June 2019 using CATI (Computer Aided Telephone Interviews). The average length of each interview was 30 minutes and the interviewees were all senior executives in corporate IT management functions, working for companies and Public Sector organizations across 32 countries.

The interviews this year were based on a questionnaire of 45 questions, with the actual interview consisting of a subset of these questions depending on the interviewee's role in the organization. The quantitative research study was complemented by additional in-depth interviews to provide greater insight into certain subject areas and to inform the analysis and commentary. The main themes for all survey questions remained the same, though a few objective responses were also added for the first time this year. Quality measures were put in place to ensure the questionnaire was understood, answered accurately and completed in a timely manner by the interviewee.

For this year's research, we selected only organizations with more than 1,000 employees (in the respondent's national market) – an approach used for the last four years to provide us with valid trending data.

Research participants were selected so as to ensure sufficient coverage of different regions and vertical markets to provide industry specific insight into the quality assurance and testing issues within each sector.

With the inclusion of product heads/CTO for the fourth time and VP Directors of Research & Development for the first time, we are able to bring in their views and insights in the space of product, engineering and digital manufacturing services for Automotive, HealthCare and Life Sciences and High-Tech Sector.

The research sample consists mainly of senior-level IT executives as shown in Fig 17.

To ensure a robust and substantive market research study, the recruited sample must be

statistically representative of the population in terms of its size and demographic profile.

The required sample size varies depending on the population it represents – usually expressed as a ratio or incidence rate. In a business-to-business (B2B) market research study, the average recommended sample size is 100 companies. This is lower than the average sample size used for business-to-consumer (B2C) market research because whole organizations are being researched, rather than individuals.

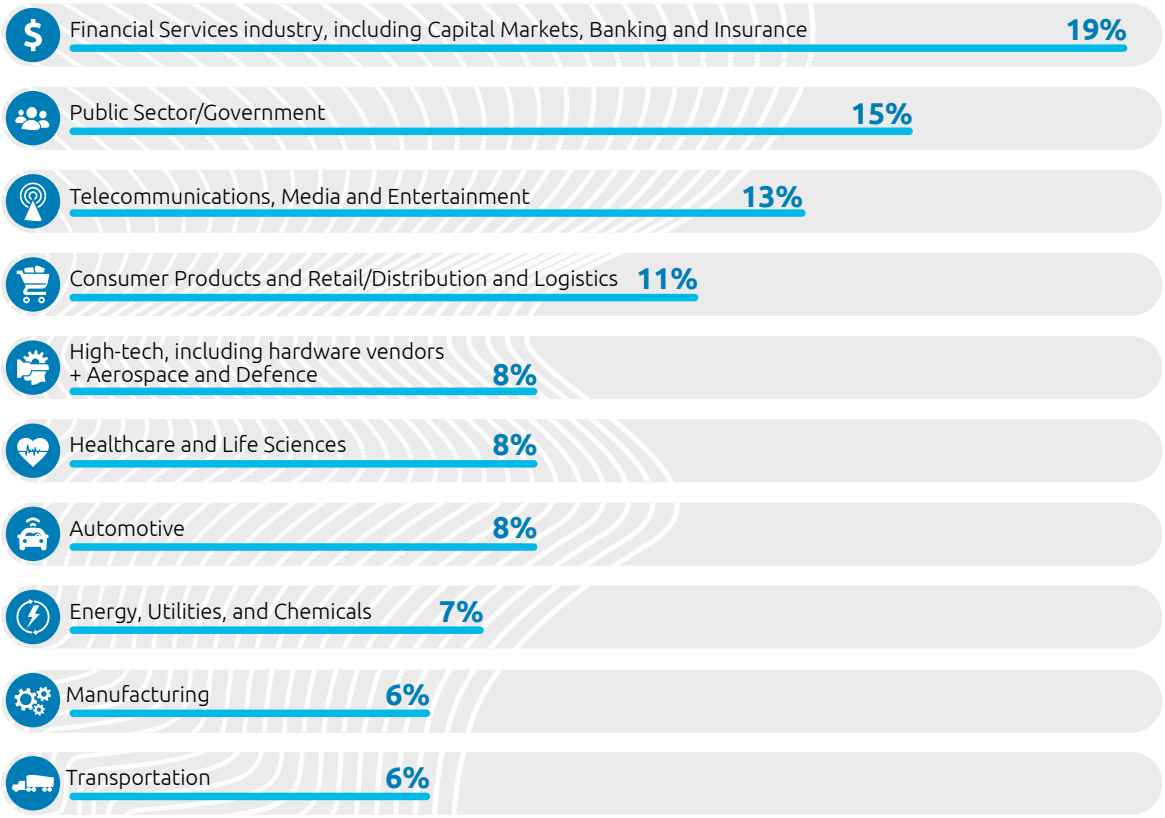
As mentioned above, the B2B market research conducted for the World Quality Report 2019-20 is based on a sample of 1,725 interviews from enterprises with more than 1,000 employees (26%), organizations with more than 5000 employees (34%) and companies with more than 10000 employees (40%). The approach and sample size used for the research this year enables direct comparisons of the current results to be made with previous research studies conducted for the report, where the same question was asked.

During the interviews, the research questions asked of each participant were linked to the respondent's job title and the answers he/she provided to previous questions where applicable. For this reason, the base number of respondents for each survey question shown in the graphs is not always the full 1,725 sample size.

The survey questionnaire was devised by Digital Assurance and Quality Engineering experts in Capgemini, Sogeti and Micro Focus (sponsors of the research study), in consultation with Coleman Parkes Research. The 45 question survey covered a range of software quality engineering and digital assurance subjects, enriched by qualitative data obtained from the additional in-depth interviews.

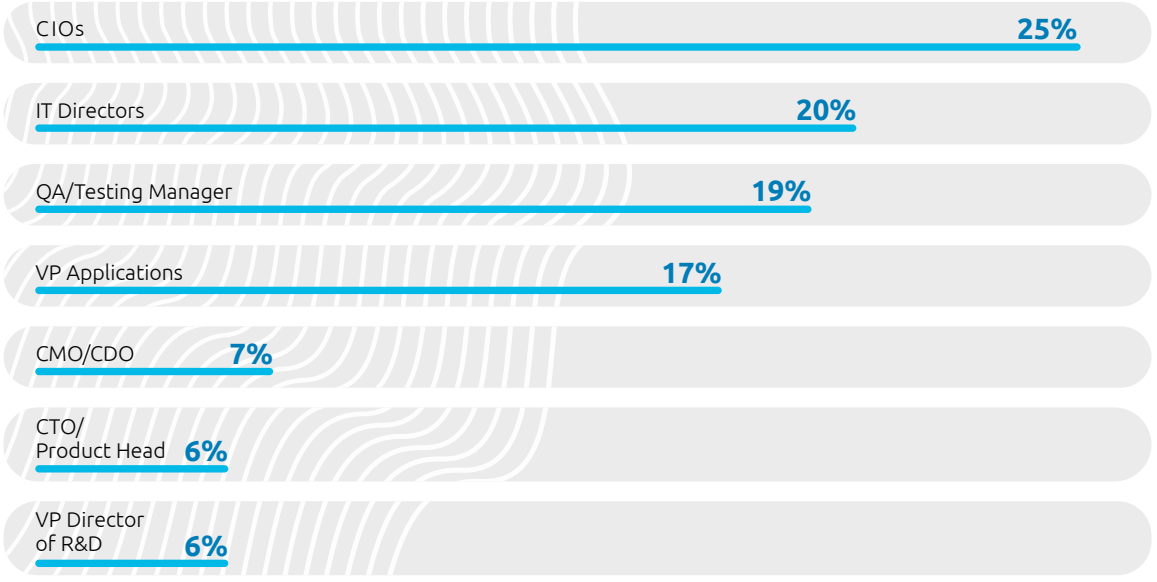
Interviews by Sectors

Fig 16



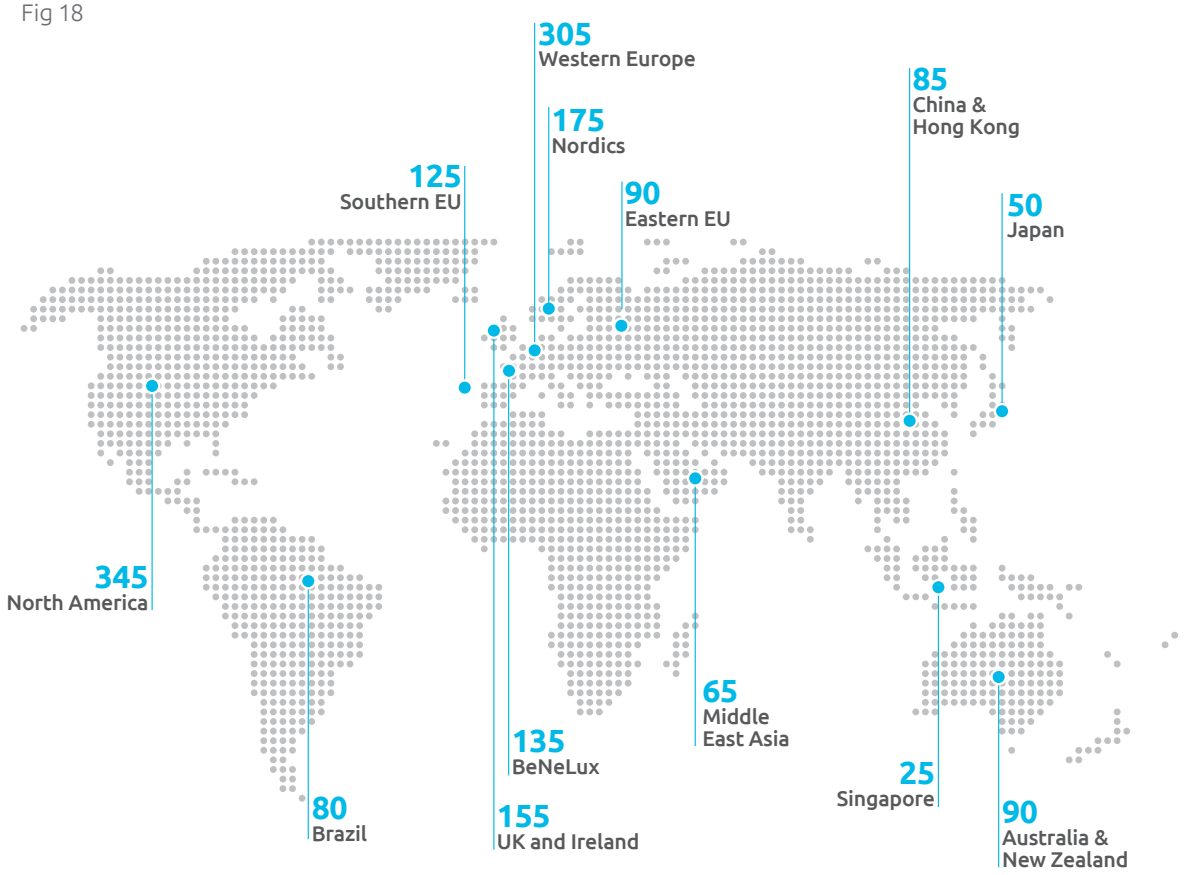
Interviews by Job-titles

Fig 17



Interviews by Region

Fig 18



32 Countries

Country	# of respondents
USA	280
Canada	65
France	150
Germany	130
Switzerland	25
Netherlands	100
Belgium and Luxembourg	35
UK	125
Ireland	30
Sweden	85
Norway	30

Country	# of respondents
Denmark	30
Finland	30
Italy	50
Spain	40
Portugal	35
Poland	30
Hungary	30
Czech Republic	30
Brazil	80
New Zealand	10
Australia	80

Country	# of respondents
China	60
Hong Kong	25
Singapore	25
Japan	50
UAE (excluding Dubai, Abu Dhabi)	15
Qatar	10
Dubai	10
Abu Dhabi	10
Saudi Arabia	10
Jordan & Bahrain	10

About the Sponsors

World Quality Report 2019-20

About Capgemini and Sogeti

A global leader in consulting, technology services and digital transformation, Capgemini is at the forefront of innovation to address the entire breadth of clients' opportunities in the evolving world of cloud, digital and platforms. Building on its strong 50-year heritage and deep industry-specific expertise, Capgemini enables organizations to realize their business ambitions through an array of services from strategy to operations. Capgemini is driven by the conviction that the business value of technology comes from and through people. It is a multicultural company of over 200,000 team members in more than 40 countries. The Group reported 2018 global revenues of EUR 13.2 billion.

Part of the Capgemini Group, Sogeti operates in more than 100 locations globally. Working closely with clients and partners to take full advantage of the opportunities of technology, Sogeti combines agility and speed of implementation to tailor innovative future-focused solutions in Digital Assurance and Testing, Cloud and Cybersecurity, all fueled by AI and automation. With its hands-on 'value in the making' approach and passion for technology, Sogeti helps organizations implement their digital journeys at speed.

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Thank you

Capgemini, Sogeti and Micro Focus would like to thank

The 1,725 IT executives who took part in the research study this year for their time and contribution to the report. In accordance with the UK Market Research Society (MRS) Code of Conduct (under which this survey was carried out) the identity of the participants in the research study and their responses remain confidential and are not available to the sponsors.

All the business leaders and subject matter experts who provided valuable insight into their respective areas of expertise and market experience, including the authors of country and industry sections and subject-matter experts from Capgemini, Sogeti and Micro Focus.

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*All research carried out by Coleman Parkes Research is conducted in compliance with the Code of Conduct and guidelines set out by the MRS in the UK, as well as the legal obligations under the Data Protection Act 1998.

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