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World Quality Report

2020-21 I TWELFTH EDITION

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World Quality Report

2020-21

Twelfth Edition

Contents

Mark Buenen
Global Leader
Digital Assurance and Quality
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Introduction

Welcome to the 12th edition of the World Quality Report. It's a source of great pride to us here at Capgemini to know that its publication has for many people become a calendar event – something they look forward to receiving, and to reading.

Our purpose in these pages is not only to assess the current climate of global quality assurance (QA), but also to provide you with best practices and expert recommendations on how you and your teams can keep on improving quality and test activities. This year's survey reconfirms that quality of IT remains a critical success factor. The most important aspect of this is the degree to which organizations remain committed to the very principle of quality. That commitment is, if anything, higher than ever.

We also see continuity in specific trends. For instance, year on year, there is a general shift towards agile and DevOps development environments; the use of test automation is growing, as for most organizations it is still not at the level required; so, too, is interest in the use of smart tools and techniques; and there is steady progress towards embedding QA practices in every part of the software development lifecycle. It is reassuring that 69% of the organizations interviewed in this survey feel they always or virtually always meet their quality goals.

The other constant is speed. Achieving not just quality, but value, at speed remains the focus of quality transformation, and that's why we're seeing growth in test automation, and in shift-left, and more. Speeding up the development cycles and achieving the right levels of quality is not easy. One of the main challenges noted this year is the lack of the right testing methodologies for teams, as reported by 55% of respondents.

This report provides various recommendations and best practices for how organizations can overcome these challenges. In addition, I would like to point out that at Capgemini and Sogeti, we published earlier this year "Quality for DevOps Teams" as a complete guide for agile and DevOps teams on how to achieve quality in their endeavors.
For more information, please visit www.tmap.net and click on the 'Our books' tab.

Not everything is a constant, though. There's one major thing in this report that is completely new. I refer, of course, to COVID-19, and its effects not just on the disciplines covered in our analysis, but also on business as a whole and indeed, on the entire world. In this survey, we also analyzed how the new reality is likely to speed up the further transformation of quality and test activities.

Finally, I thank the many people who contributed to our report this year. In addition to the analysis of our own experts and of those from our partner Micro Focus, we are grateful to the many senior figures from client organizations who provided insights and best practices. We thank, too, all the 1,750 people worldwide whose responses have helped shape our understanding of the worldwide trends in quality and testing.

I hope that this 12th World Quality Report is a source of inspiration for you to further enhance the quality and test activities within and across all your teams and programs.

Raffi Margaliot
Senior Vice President and General Manager, Application Delivery Management
Micro Focus

This past year has seen unprecedented challenges across every industry and in every country. The COVID-19 pandemic has severely impacted QA and IT strategy, forcing teams to become more agile, to do even more with even less, and to adjust to new ways of working with their colleagues. However, as we noted in previous editions of the World Quality Report, organizations have been steadily improving and accelerating their ability to deliver value with high quality and security, and this momentum has equipped them to deal with the changes we are all facing.

This year's World Quality Report shows that QA has transitioned from being an independent function in a separate team, towards becoming an integrated part of the software delivery team, with responsibilities reaching beyond testing and finding defects. QA engineers are now charged with enabling the entire team to achieve their quality objectives, and incorporating better engineering practices and state-of-the-art techniques such as Artificial Intelligence and Machine Learning to achieve these aims.

The World Quality Report notes that organizations that had already begun their digital transformation prior to the onset of the pandemic were in a better position to adjust than those still working with legacy practices, who have been prompted to overhaul their approach to software delivery in general, and to QA and automation in particular. Much more than an account of respondents' answers to the questions in the survey, the World Quality Report includes a wealth of key action items across all aspects of QA, enabling the reader to identify areas in their organization that could be improved, and make the changes necessary to become even more effective.

With AI and ML now an integral part of our continuous testing and quality management tools, Micro Focus helps customers to advance their software modernization initiatives and meet demand for increased test coverage, better performance, and high security across an unparalleled range of web and mobile devices and environments. We enable organizations to make the cultural shift demanded by today's reality, helping them to succeed in the face of the global mandate to be even more productive with less budget and fewer resources.

Finally, I'd like to convey my appreciation and thanks to our friends and partners at Capgemini and Sogeti, and everyone who has worked tirelessly to produce this edition of the World Quality Report.

Executive Summary

WORLD QUALITY REPORT 2020-21

Sathish Natarajan
Group Vice President
Head of Digital Assurance and Quality Engineering
Capgemini North America

Dhiraj Sinha
Vice President
Financial Services, Digital Assurance and Quality Engineering, APAC Region

Growing expectations from QA.

Can we meet them?

Yes. We can.

This has been a year of steady and encouraging progress. Acceleration in QA transformation is visible, and we think that also contributed to a great extent in the resilience shown by the QA and information technology (IT) teams in the face of the COVID crisis.

For instance, and as you'll see in more detail in the rest of this executive summary, quality is now being assured by following better engineering practices, yet the testing mindset remains as relevant as before. The adoption of agile and DevOps continues to grow. The uptake of artificial intelligence (AI) and machine learning (ML) in QA has been growing gradually, with some of the use cases maturing and others getting evaluated. Test automation is moving forward too, and is becoming more intelligent and comprehensive. In some cases, the pace of change has been hampered by legacy practices, budget constraints, and skills gaps, but nonetheless, the momentum has been encouraging.

Expectations of QA have been steadily increasing. There's an upward trend in almost every case for the objectives for which we have previous data. These include the need to support business growth and the importance of ensuring end-user satisfaction. Both of these indicate that QA is no longer seen as a backroom discipline, divorced from the rest of the organization. If you hear fewer soundbites about QA and more about digital transformation, it's not because QA

has ceased to be relevant, but because the contribution of QA is implicit in the success of the digital transformation.

The graph below (see Fig 01) shows responses to new criteria that were introduced this year. Time to market and test automation are almost as significant as other objectives, and it will be interesting to see how they change over the next year.

However, it's the bottom bar that's likely to prove the most intriguing. It won't be an exaggeration if we say that out of all the software disciplines, QA has witnessed the most rapid transformation. QA has been steadily evolving – from an independent function to an integrated function, and now to an inclusive function. Also, the role of the QA practitioner is transforming from testing and finding defects, to ensuring that other engineering team members inculcate quality in their way of working. They need to do this by enabling them and by removing any impediments on their way to achieving quality objectives. QA is not only shifting left but also moving right. We see more and more enterprises talk about exploratory testing, chaos engineering, and ensuring that the product is experienced the way end users will experience it in real life before releasing it to the market.

Fig 01 Objectives of Quality Assurance and Testing in the organization

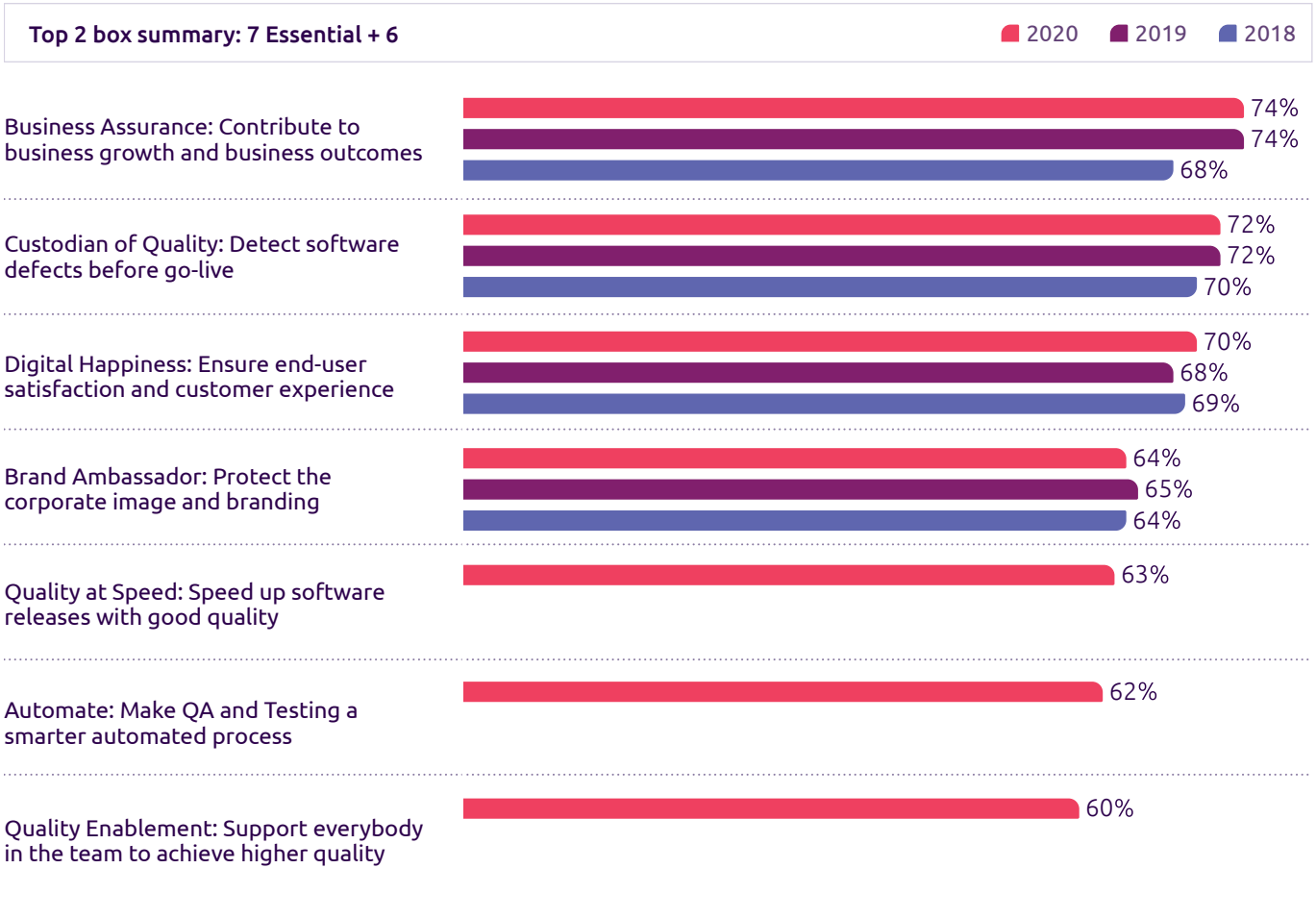
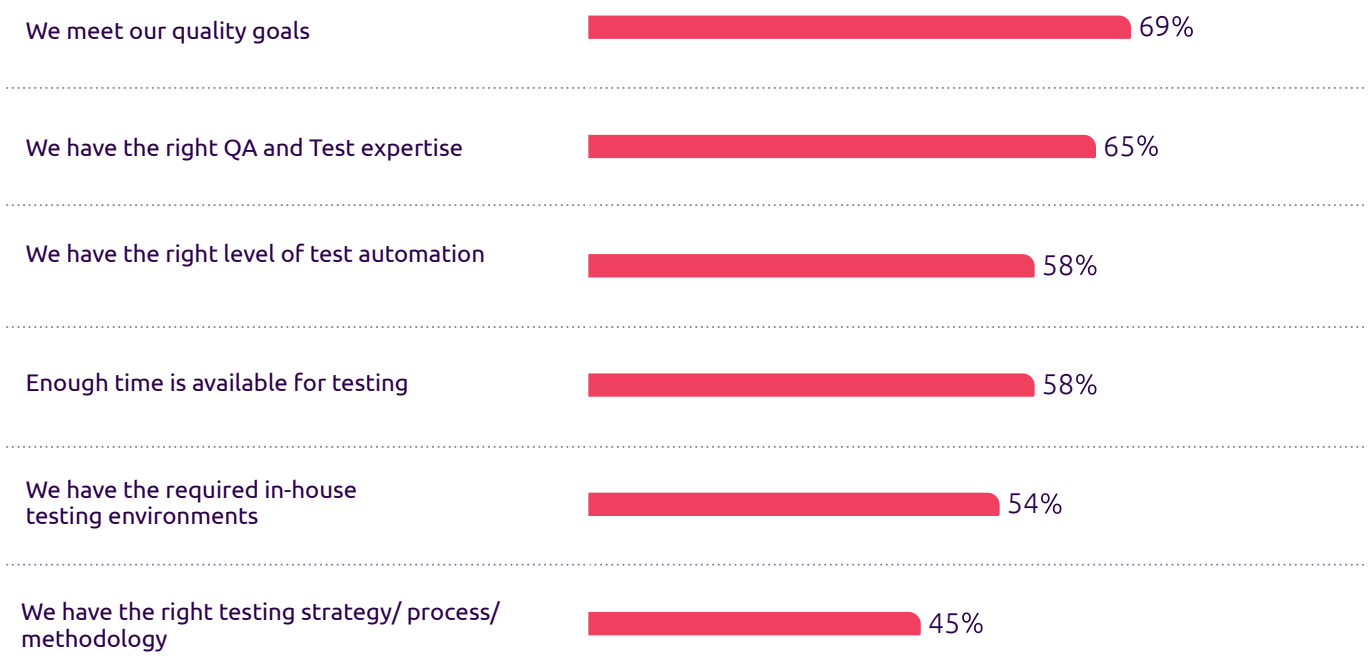


Fig 02 How often do your QA teams achieve the following targets when testing key applications?



An entirely new question for this year gives further grounds for optimism (see Fig 02). More than two-thirds (69%) of our respondents felt they always meet their quality goals, and almost as many (65%) felt they had the right expertise.

Figures for test automation and for the time available for testing were also quite high, although we know, first, that automation is still in a growth phase, and second, that testing teams in the field often feel under more time pressure than is indicated here. Next year, we'll perhaps be able to see if there is a reality check, or whether there is indeed consistent confidence about the extent to which targets are being met.

So far, then, so promising. Except, of course, that this year brought an entirely new factor into the QA picture – a factor that no one in this field predicted.

That, of course, was the arrival of COVID-19. The coronavirus pandemic has been a major challenge, but as we shall see, both in this executive summary and elsewhere in the report, it has also acted as an accelerant, encouraging organizations and teams to do more things – and to do them better.

Key Findings
World Quality Report 2020-21

QA orchestration in agile and DevOps

The adoption of agile and DevOps is steadily increasing, resulting in QA teams becoming orchestrators of quality. The risk and complexity associated with software development has gone up significantly, creating even more pressure to assure high quality. At the same time, the need to do it faster and cheaper is more important than ever. So, QA teams need to use the right tool sets and technologies, the right skilled professionals, and the fit-for-purpose processes to get it right. We see a trend towards wanting QA engineers who have developer type skills, who yet retain their quality mindset and business-cum-user centricity.

Is this expecting too much? Yes, we think so. Only a few QA professionals can have all these skills in their repertoire. That's why organizations are experimenting with the QA operational structure, with the way QA teams work, and with the skill acquisition and training of QA professionals.

Quality assurance is no longer a metric that is only of technical interest. It absolutely has to ensure that software works for employees, suppliers, and customers, and this year's report demonstrates the continuing growth in acceptance of this truth.

Artificial intelligence and machine learning

As last year, so this year. Expectations of the benefits that AI and ML can bring to quality assurance remain high, but while adoption is on the increase, and some organizations are blazing trails, there are few signs of significant general progress. Partly, this is because relevant skill sets still aren't in place; and partly, the arrival of the COVID-19 pandemic has disrupted schedules, budgets, and plans.

Nonetheless, enthusiasm hasn't diminished: organizations are putting AI high among their selection criteria for new QA solutions and tools, and almost 90% of respondents to this year's survey said AI now formed the biggest growth area in their test activities. It seems pretty clear they feel smart technologies will increase cost-efficiency, reduce the need for manual testing, shorten time to market – and, most importantly of all, help to create and sustain a virtuous circle of continuous quality improvements.

Budgets and cost containment

Quality assurance budgets have always been challenging, but the pressures have increased this year. This is partly because of the economic impact of the COVID-19 pandemic, but it's also because digital transformation has increased the online real estate that QA teams have to manage.

As a result, organizations are being forced to innovate and become more efficient. The main focus remains manpower cost reduction, but some organizations are also looking at deriving the best out of their tool investments, moving test environments to the cloud, and looking for efficiencies from technologies including AI, machine learning, and test automation.

The other aspect is increasing difficulty in accounting for the QA budget as it becomes an integral part of the end-to-end lifecycle. However, if the net outcomes are a universally shared commitment to quality and an efficient QA organization, that will be a great thing.

Test automation

Automation has become core to QA transformation. The good thing we saw this year is that more and more practitioners are talking about in-sprint automation, about

automation in all parts of QA lifecycle and not just in execution, and also about doing it smartly.

While the momentum could have been higher, the automation scores have mostly risen since last year. Also, the capability of automation tools being used seems to satisfy many organizations, but the signs are that benefits aren't being fully realized: only around a third of respondents (37%) felt they were currently getting a return on their investment. It really depends on how that return is being measured and communicated to the relevant stakeholders. Another factor may be that the tools are getting smarter, but the teams are not yet sufficiently skilled to take full advantage of them.

Overall, however, we are happy to note the progress. Organizations are working their way forwards, in spite of the increasing complexity of applications and the business processes that they support – and they are achieving greater control and transparency of their QA activities.

Test environment management (TEM) and test data management (TDM)

Approaches to TEM and to TDM are still evolving, but there is reason for optimism. In our survey responses, we observed an increase in overall satisfaction with TEM and TDM outcomes, though we think that on the ground these remain challenging. More organizations are adopting cloud and cloud-based technologies for managing their TEM and TDM needs. They are also implementing tools for test data management, though most still use them only for data masking purposes. Service and data virtualization techniques are also becoming mainstream, and are being used for TEM and TDM. We also witnessed more organizations moving to create a specialized shared services organization for TEM and TDM.

It was also interesting to note that process and governance came out as a bigger challenge than technology in this area.

Impact of COVID-19

The effect of the pandemic on testing and quality assurance has varied by sector, and those with legacy working practices have been particularly badly hit. Circumstances have also forced the pace of change, with faster adoption of distributed agile, more widespread use of collaboration tools, greater use of data masking, and more real-time status monitoring across the whole QA function.

At a macro level, the pressures of COVID-19 have accelerated digital transformation programs, with all the QA consequences this implies. For instance, the growth of online business has increased the demand for security testing.

In general, it's heartening to note that, while the challenges have been many, there are signs that organizations are taking advantage of the upheaval to improve their entire approach to QA, with greater shared commitment, and greater determination to succeed.

Key Recommendations

World Quality Report 2020-21

QA orchestration in agile and DevOps

Don't silo responsibility for QA. Share it.

Quality practices should be integrated into every part of the lifecycle – and should be part of everyone's mindset.

Spread the word.

Software quality isn't just an IT thing, either. People should spread the word, because the rest of the business needs to understand that if it helps IT to get things right, everyone wins.

Be part of the business.

IT can also help itself by getting closer to the business, learning its skills, and taking time to understand its objectives.

Make room for dashboards.

Quality dashboards make everything more visible and straightforward.

Listen more to users.

"Is this working for you? Tell us what you think." Asking and listening will make things better, and will make customers happier.

Artificial intelligence and machine learning

Focus on what matters.

If you identify and prioritize use cases, you'll be able to increase the overall capacity of your QA function, and enable your teams to concentrate their efforts. The area of greatest need is likely to deliver the greatest benefit.

Keep learning.

There's always something new to learn. To get the most out of AI in quality assurance, teams need to strengthen their knowledge and experience of the tools, of overall QA and IT strategy, and of the commercial objectives of the business as a whole.

Have a toolkit.

Encourage teams to explore the continuous adoption of toolsets involving AI functionality. Invest in the cloud solutions that can provide the needed GPUs for teams to fail fast and learn.

It's also worth considering building portfolios of common toolsets and data libraries. This makes the development of AI-based test strategies much easier to pursue.

Testing AI systems: have a strategy.

Testing AI itself is a particular challenge – and it's a moving target. Learning from best practice – from the automotive sector, for instance – is a good start, especially when we are going to continue witnessing new innovations and strategies.

Budgets and cost containment

Greater savings can be achieved by using test infrastructure smartly.

Maturity and the adoption of cloud-based technologies provide an excellent opportunity for organizations to optimize their test environment and test tool licensing costs.

Use advances in analytics, AI, and machine learning to make testing smarter.

Organizations should have a solid plan in place to improve the efficiency and effectiveness of QA using advances in analytics, AI, and machine learning.

Similarly, organizations should plan their investment in test automation up-front, so as to realize future cost savings in addition to the time-to-market benefits.

Be prepared to pay well for smarter talent.

Hiring people on price rather than on quality is a false economy. Talented people are more likely to have broader development and testing skill sets, and greater business aptitude – so they're likely to help increase efficiency and boost business, too.

Don't put all key initiatives on hold. Strive to be more efficient instead.

Aim to identify QA initiatives with the greatest potential, and pool your best thinking to find the smartest, shortest routes to success. If that means thinking outside the box – and outside the team – so be it.

Test automation

Change the status quo.

Testing will always be squeezed in the software development lifecycle. Introducing more automation – and pursuing it vigorously – is the only answer.

Think ahead.

Choosing tools that will keep pace with dynamic changes to applications is very important.

Choose the right framework.

Opt for design automation frameworks that are intuitive, dynamic, have self-spinning environments and algorithm-based prioritized scoping, and that can self-provision test data.

Balance automation against skills needs.

Organizations need either to lessen dependency on skills or to make automation inclusive.

Don't think one size fits all.

A multi-tool approach, instead of one-tool-for-everything, can be beneficial if applied correctly.

Get smart.

Take the heat off: let AI and machine learning tackle the technical challenges in automation.

Test environment management (TEM) and test data management (TDM)

Create a shared center of excellence for TEM/TDM.

A shared center of excellence (CoE) should be created to service the TEM and TDM requirements within an organization. This team should create a strategic framework which each of the project teams can use.

Get as much value as you can out of your tool investment.

Teams should make every effort to plan and implement the various features that their TDM and TEM tools provide. They should also train their team members and measure and report regularly on the benefits.

Have strong governance in place.

It's essential to have a mature approach to the governance of managing the complete lifecycle, from raising the demand to de-commissioning and archiving the test environment and test data. QA teams need to work jointly with the TEM/TDM center of excellence to forecast demand and achieve visibility of what is available.

Getting ready to succeed in a post-COVID world

Be better prepared for business continuity.

Run disaster planning sessions more often, factoring in not just workforce issues but systems availability. Test the application architecture, and ensure it will be able to adapt in line with any changes to business models.

Focus more on security.

More business is online, and more people are working remotely – which means there is greater vulnerability. Prevention is better than cure, but make sure you also have a good Plan B for any breaches.

Don't look at COVID-19 as a way to cut costs, but as an opportunity to transform.

Cost-cutting in a crisis may only bring short-term gains. Investing now in digital transformation and in changes to the business model will deliver greater benefits, and over a longer timeframe. It's also a good idea to ensure the QA strategy stays in step with these developments.

Continue to use the best practices adopted during the pandemic.

The old ways aren't always the best. If you've been doing things differently in 2020, keep what works. For example, ensure applications remain responsive to business changes; keep cutting back on unnecessary physical infrastructure and travel needs; and sustain a new, more collaborative, and more remote way of working, in ways that suit your circumstances.

Energy, enthusiasm, and determination

As we've seen, COVID-19 has created significant problems for business, but it has also sharpened minds and accelerated the pace of change – from specific areas of QA such as the use of crowd testing, to the faster implementation of enterprise-wide digital transformation initiatives.

These pressures are mostly being greeted with optimism and enthusiasm. For example, organizations are finding out smarter ways to tackle the cost efficiency issues this year. They are more open to optimize tests by applying AI in QA, improving usage of test automation and test tools and maturing the test environment and test data management practices.

Several factors are increasing the likelihood of success, and you'll find plenty of detail in these pages. For now, though, we'll highlight three of them.

The first is that the trend to embed quality into every stage of the development process is continuing. It's encouraging to see how continuous testing is becoming mainstream and AI use cases for QA are maturing. Indeed, there are signs that QA will, in time, become a specialized quality-enabling function. This will be a good thing.

The second one is related to the first. It's the move towards multi-skilled team members – people who bring a mix of development, data, testing, and business skills. Without these talented individuals, end-to-end quality assurance will be much slower to arrive.

The final factor relates to the mindset. Partly because of the pandemic, and partly because the gradual improvements of recent years are beginning to bear fruit, we sense a greater willingness to succeed. It's a sense that many people share, both within and across teams, and across disciplines, geographies, and sectors.

Can QA teams meet the growing expectations?

Yes. We can.

Current Trends in Quality Assurance & Testing

QA orchestration in agile & DevOps

A steady evolution – and what's needed to accelerate the pace

Régis Curien
Head of Digital Assurance and Quality Engineering, Sogeti France

Albert Tort
Chief Technology Officer, Sogeti Spain

Tal Levi Joseph
Head of Product Management Application Lifecycle Management Portfolio Micro Focus

Maheshwar Kanitkar
Vice President, Global Sales Leader for Digital Assurance & Quality Engineering Europe

Narrowing the skills gap

"The gap between 'black box' testers and developers is narrowing. We're finding people in coding are growing more comfortable with testing, and vice versa. In fact, over the last five years, I'd say that testers are close to becoming developers in their own right."

Tribikram Rath
Director, QA Engineering
General Electric

In general, it seems there are no major changes either of pace or of direction this year in the adoption of agile and DevOps in quality assurance (QA). It's a case of steady evolution, rather than of major revolution, as organizations integrate these approaches into their testing practices. Our experience is that many of those who aren't yet moving in this direction are at least declaring their intention to do so.

It's worth reminding ourselves of what's prompting this steady transition. The world of business in general, and of technology in particular, is prone to regard new developments as intrinsically positive – but as in these many cases, so here, the adoption of agile and DevOps should be seen not as a destination in itself, but as a means to a much more important end – and that objective is better overall quality. These development methodologies can help to connect the execution of the QA process more directly to the needs of the business – and, in the new climate created by the COVID-19 pandemic, the rate at which this is happening is increasing.

It's interesting to note how mixed the QA picture is. This year and also in previous years, the World Quality Report has noted the extent to which functions are merging, such that testing is becoming a concurrent part of the software development lifecycle, practiced by people with hybrid skills. But at the same time, we are seeing the introduction of more centers of excellence, providing specific services as well as overall software development governance.

Indeed, quality assurance now addresses many more attributes, including functional, performance, security, and usability. What's more, it does this at several different levels, such as at the unit level, the interface level, and end-to-end. All this creates a need for multi-disciplinary skills on the one hand, and specialization on the other.

Another perennial topic in these pages is the need for training – but this year, we're also seeing greater calls for a change in organizational culture. As we shall shortly see in this section, it's clear from this year's report that respondents from different countries seem to interpret that word 'culture'

in different ways. However, in addition, it's our view that, to a great extent, the culture or mindset of a business emerges from something far more tangible – and that is its org chart. The blending of testing and development roles, and the retention of specialist areas of excellence – all of this helps to define an organization, and to create the environment in which it moves.

Incidentally, it's heartening to see the extent to which people both inside and outside the software development function are recognizing the growing importance of data, and of interpreting it using smart analytics and intelligent insight.

Increasing levels of adoption

And so, to the survey data. The evolution of agile and DevOps adoption is illustrated in this year's figures by the degree to which these environments are being used for testing. On average, we see both agile and DevOps being used more by a percentage point over last year – but this average doesn't tell the whole story. For example, in agile and DevOps models, 40% of our respondents said 30% of their overall project effort is allocated to testing. In general, it is clear that the adoption of agile or DevOps is part of a process of continuous improvement.

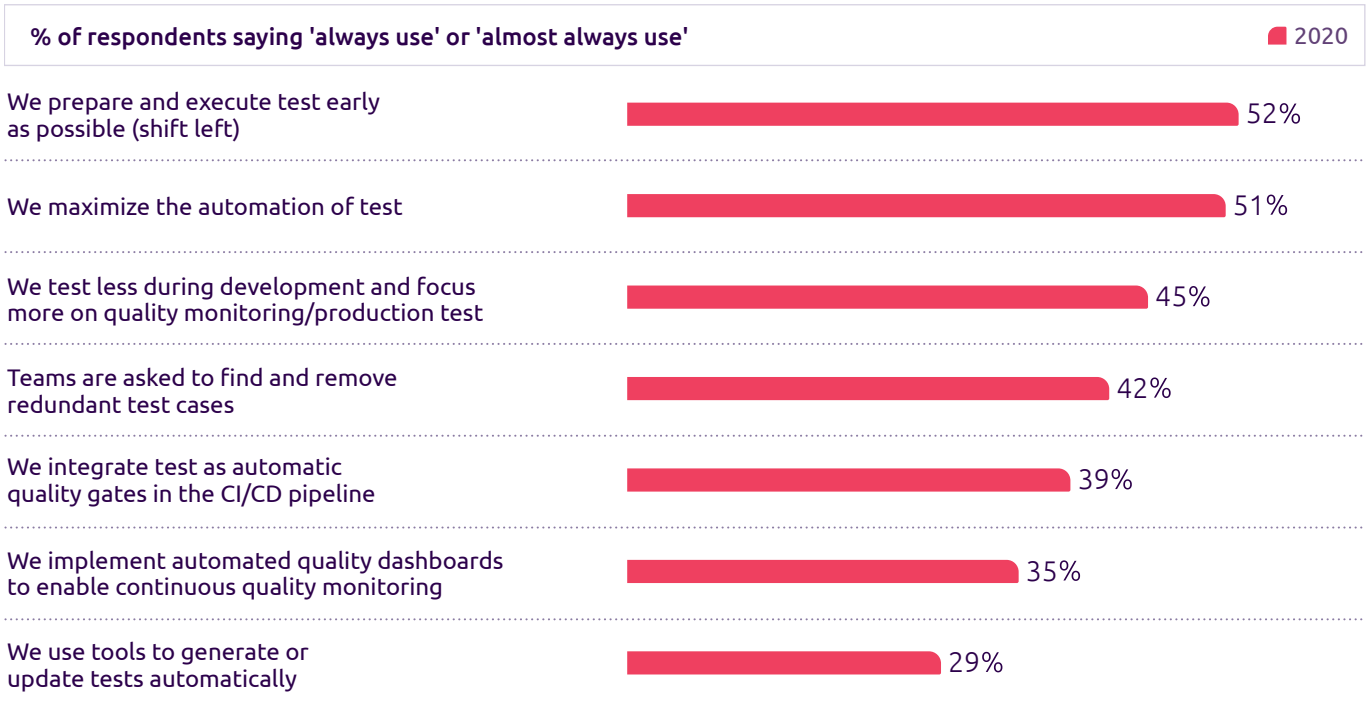
There is still some way to go. For one thing, there is quite a wide variation between individual countries: for instance, almost half of US respondents using agile (47%) said they do so for more than 30% of their overall test effort, whereas only 11% of Italian respondents and 4% of UK respondents said the same. For another thing, we note that overall, around one in five respondents using Waterfall said they are still doing so for more than half of their overall test effort. Nonetheless, it seems clear to us that the center of gravity is shifting.

Agile is being pervasive

> *"We've been an agile organization, especially in development, for the last few years now, and we've been working that way in other areas of the organization, too – for instance, in governance and finance."*

Anders Lemon
Head of Architecture, Application infrastructure, Development Platform and Quality Process, Försäkringskassen

Fig 03 Approaches to speed up and optimize testing in agile and DevOps development



Focus on innovation

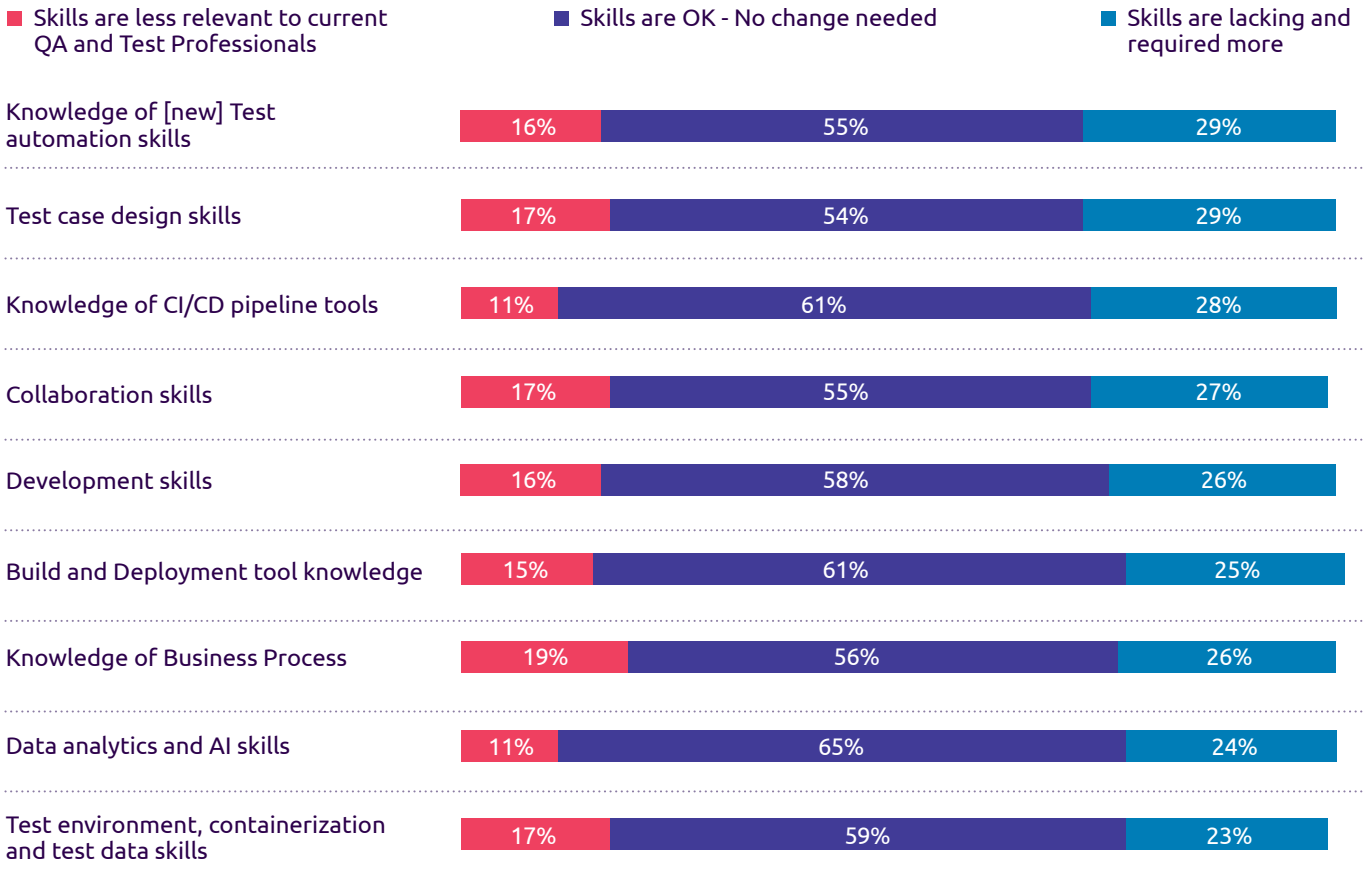
"Over the last three years, we've increased our focus on innovation. As part of this, we've invested in DevOps, which helps us to deliver faster. There is a company-wide DevOps focus group of which we in QA are part, alongside colleagues in other areas including infrastructure and business analysis."

Hemant Anugonda
Assistant Vice President
TMNAS

We also asked respondents about the challenges they face in applying testing to agile development. Only 1% of them said they faced no real difficulties in this respect. It was a little surprising to find that the most common challenge (50%) was a reported difficulty in aligning appropriate tools for automated testing. However, this may perhaps be explained by the fact that 42% of respondents reported a lack of professional test expertise in agile teams – and so this lack of skills may explain the uncertainty about identifying and applying the right tools.

Different approaches to the acceleration and optimization of testing are possible in agile and DevOps developments, and we asked respondents about this (see Fig 04). We were a little surprised not to see dashboards feature more highly: visibility is one of the important concepts of agile, and the implementation of quality dashboards can make a considerable difference to implementation. Indeed, we think their use is becoming a must-have and not nice-to-have component of projects. Sharing is very important, and quality must be everybody's concern. However, the emphasis given to early testing and to automation are to be expected.

Fig 04 To what extend the skills needed from the QA and test professionals need to change?



Discipline and determination

"But whatever the case, agile is pretty much the go-to approach. It enables us to find fast, and fix fast. For us, with agile, the key word is discipline. It's about the determination to do it right."

Geoff Meyer
Validation Architect
Dell EMC

User experience is key in quality assurance, which is why it's essential to find any anomalies while still in production. We asked respondents whether they proactively monitor and review production logs for incidents, and performance trends, in order to identify application issues and potential defects even before end-users might notice them. The vast majority (89%) said they do this always, usually, or frequently; only 11% said they do this only sometimes or occasionally. We believe the 89% figure is rather high: in our experience, production monitoring is not happening as often as it might. In the case of the 28% who specifically said they always do this, it may be an indication that the process has been automated here.

Which metrics are teams using to track applications quality? Code coverage by test was the most important indicator, with 53% of respondents saying they always or almost always use it. This is compliant with agile test pyramid good practices, although it can be argued that this is more of a development indicator, since it measures unit tests. Almost as high in response, with 51% saying always or almost always, was risk covered by test. This is particularly significant: if test strategy is based on risk, it's a very good thing.

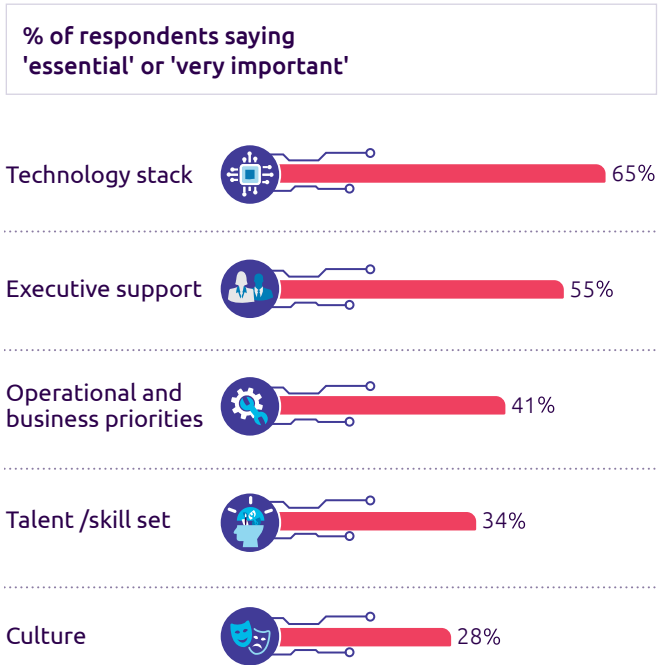
Our survey also highlights the continuing need, driven by agile and DevOps environments, to extend team skills, and in a variety of areas, including technical and development, operations, and also softer skills such as collaboration. However, the areas of greatest skills needs, mentioned by 28% to 29% of respondents, were, in growing order of importance, knowledge of CI/CD pipelines tools; test case design skills; and, at the top, test automation skills. That said, though, respondents mentioning test automation skills needs have dropped from 31% last year to 29% this time, which reflects our own experience: organizations do now seem to have more skills on board in this area.

Technology – or business?

Out of all the insights relating to the agile and DevOps theme, perhaps the greatest surprise for us in this year's survey was the response to a question about the importance of various criteria for successful agile and DevOps adoption (see Fig 05). The technology stack was rated as essential or almost essential by 65% of respondents, while skill sets and organizational culture came at the bottom, with 34% and 28% respectively rating these highly. Operational and business priorities were rated highly by 41% of respondents.

How can this be? Maybe some respondents thought these criteria were a given, or maybe they interpreted these options differently. That's certainly a possibility: we noted wide variations between countries in response to this question. For instance, the highest figure for skills needs was Poland, with 63%, while the lowest was Brazil, with just 5%. Similarly, for culture, the highest figure was Sweden, with 69%, and the lowest was once again Brazil, with only 2%. (Brazil's perceived technology stack need was very high, at 98%.) The concept of culture could mean different things in different countries, and may therefore be weighted differently for people.

Fig 05 How important are the following aspects for successful agile and DevOps adoption?



Regardless of what may have prompted some of these responses, we remain resolute in our own view that success in agile and DevOps adoption is predicated on the extent to which developments are business-driven. We derive this opinion not just from our own experience in the field, but from the pervasive sense of a commercial imperative that emerges from many other areas of this year's report.

QA orchestration in agile & DevOps: call to action

Don’t silo responsibility for QA. Share it.

Implicit in the adoption of agile and DevOps is a more collaborative approach to business processes, including quality assurance and testing. Organizations should aim as much as possible to make QA a shared responsibility, integrating quality practices into every part of the lifecycle. Centers of excellence should be retained only for specialist areas of QA, such as emerging AI-based routines, where it would be too costly and time-consuming to ensure all team members had the requisite skills.

Spread the word.

If quality isn’t only the responsibility of QA teams, it isn’t only the responsibility of the IT function, either. The whole organization needs to understand its importance. In particular, IT should educate the business on good practice in gathering, codifying and maintaining the data on which future software is built, and from which future insights will be derived.

Be part of the business.

IT and QA don’t only need to educate the business: they also need to learn from it. It’s true that the IT function is more business-driven these days, but there is still a degree of them-and-us. Those barriers need to go. Temporary secondments to non-IT functions, and enrolment of IT and QA people on business skills development programs, are both possibilities.

Make room for dashboards.

It’s easier to plan a direction of travel, to identify gaps and errors, and to make adjustments along the way, when everything is easily visible. Quality dashboards are key.

Listen more to users.

Production monitoring is not as common as claimed. That needs to change. Addressing this will lower risk and improve customer experience.

Artificial intelligence and machine learning

Aspiration – and adoption by degrees

Andrew Fullen
Head of Innovation and Technology,
Sogeti UK

Michel Burini
National Manager, Sogeti France

Prabakaran Karuppiah
Vice President, Financial Services
Capgemini

Rik Marselis
Principal Quality Consultant
Digital Assurance & Testing, Sogeti NL

Shiva Agolla
Regional Practice Leader,
Digital Assurance and Quality Engineering
Sogeti USA

Learning lessons, feeding back

> *"We're seeing real benefits now from AI. For instance, over the last year we've been using machine learning for testing analysis on customer usage, seeing which features are working best for people – and we're feeding that knowledge back into our development strategy."*
>
> **Suresh Dwadasi**
> Delivery head, multinational bank

When we've asked about the greatest challenges in testing key applications, the top answers for years have been not having enough time to test, and not having the right test processes and methods. This year's pandemic has only exacerbated the challenge, with digital as a prominent asset on which businesses are counting for survival.

Can one produce high-quality digital assets such as e-commerce, supply chain systems, and engineering and workforce management solutions, without spending time and money assuring quality? In other words, can a system be tested without testing it? That may sound like a pipedream, but the industry has already started talking about developing systems and processes with intelligent quality engineering capabilities. Typically, innovations are greeted with a mix of cynicism and excitement. When the status quo is challenged, the expectations run high. In our survey responses, that seems to be the case with the transformational capabilities of the application of artificial intelligence (AI) to digital assurance and quality engineering. While only time will tell the extent to which self-testing systems become a reality, it is evident that significant efficiency and speed can be derived by applying these smart technologies in business assurance, driving growth and improving outcomes across sectors.

So, while there are high expectations and some evidence of application of supervised learning as a core part of machine learning (ML) in making quality engineering (QE) smarter, adoption and application have still not reached the required maturity to show visible results. In fact, we saw that in several cases, test automation is being given higher priority, in order to find an immediate answer to the perennial need to speed up the software development lifecycle and to lower costs. This is not surprising, though, especially in a year in which schedules have been shot to pieces by the COVID-19 pandemic, and in a time when experience, speed and quality are key to the resilience of organizations.

Another reason for relatively less progress seems to be lack of required knowledge and relevant skills within organizations.

There is immense potential

"In fact, it was the World Quality Report that catalyzed our use of AI in testing. In the reports of around 2016 and 2017, you were calling it cognitive QA, and it gave us ideas. We started with test planning – including requirements analysis and traceability, impact assessments, and configuration planning. Bots can really help in these areas. We'd already seen that DevOps could enable the provisioning of test environments, and we moved on from there to test triage analysis. Until that point, we'd needed a lot of subject matter expert knowledge, and we needed those SMEs to mine through loads of data. But now, AI offers us the capability to streamline the triage process by mining failure artifacts, such as logs, past defects, past failures, source code, etc., and quickly determine potential sources of the problem – the environment, or the test case/script, or the code itself. In addition, it can be augmented to provide a recommendation as to whether it's likely a duplicate or "related to" issue which helps the order of priority in dealing with them."

Geoff Meyer
Validation Architect, Dell EMC

Identifying and prioritizing use cases

"We've been using NLP to build a test factory framework for data comparison. We've also been looking at other AI tools such as visual UI automation, with a lot of dynamic content. The execution is very fast."

Hemant Anugonda
Assistant Vice President
TMNAS

New use cases are emerging

The good news is that some companies are now working hard to change this, and are blazing the trail in the application to QE of unsupervised learning, natural language processing (NLP), and computer vision technologies. We have witnessed new use cases emerging since last year. For example, running analytics on production incidents and run-time application logs is helping not only to conduct a deep intelligent what-if analysis, but also to predict future quality, and to prescribe necessary planning in development and testing activities. This helps to improve testing by incorporating actual usage patterns into tests in a smart way. Another use case that seems to have gained traction is the use of AI for the generation and management of test data. For instance, it is being used to identify test coverage gaps compared to real user experience patterns. The same is also successfully applied to the creation of synthetic data, for example to comply with GDPR rules.

The aspirational nature of some responses to questions about AI and ML is borne out when we consider the smart QA options that organizations deem to be relevant for them this year. Well over half our total respondents (58%) said that automated root cause analysis was extremely or highly relevant, even though we suspect that many of them may not actually have applied it yet.

The provision of fit-for-purpose test data was also highly rated, at 54%. We find this less surprising, because it's likely that organizations do see the benefit here. It would be useful, in our view, if they saw fit-for-purpose test environments and defect prediction in the same way: these two options came in at 39% and 29% of respondents respectively. In fact, defect prediction is a big, obvious application for artificial intelligence. It's possible that in answering this question, people were thinking principally of prediction in terms of how many defects, when what is far more important and useful is predicting where they will be.

Testing of AI systems remains at low maturity

In addition to the application of AI and ML in QA, there is also the matter of how to test the AI systems. Do organizations have a strategy for that? It's clearly an emerging art: how do you gauge something that is learning and morphing on its own terms? Organizations are realizing they need to figure this out, and that new skills will be needed to test AI systems when it is still at its current nascent stage.

At the same time, we have also witnessed that some sectors have made a start in this area. We are seeing medical device manufacturers develop standards for the process of verifying and validating AI-based algorithms in their product lines. We are also seeing the automotive industry virtually validate AI algorithms in their advanced driver-assistance systems (ADAS) and autonomous systems.

Retaining the quality mindset

"Of course, our team members are learning new skills, in areas such as AI, analytics, and machine learning. But they still need to retain a quality mindset, that's essential."

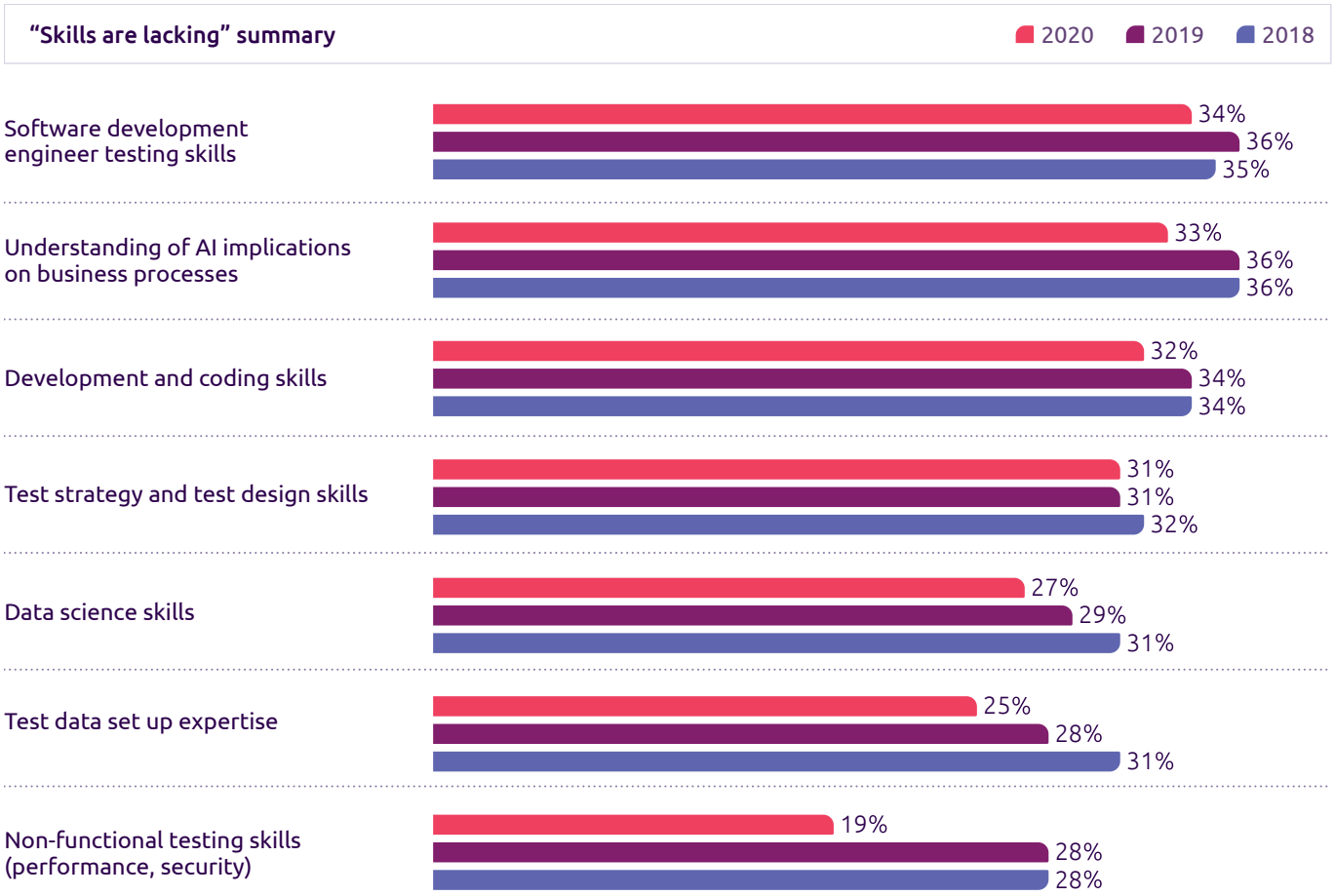
Andy Armstrong
Head of Quality Assurance & Testing
Nordea Bank

How AI impacts the test strategy – and where skills are needed

When asked about how AI impacts quality and test strategy, respondents were broadly sanguine. They seem to demonstrate they have a good grasp of how to test, and are confident their strategies will cope. That said, more than two-thirds of them (68%) said new test strategies would be needed to test AI itself. A full three-quarters of respondents (75%) said that overall, only small changes to their current test strategy were needed, possibly indicating that some of them have yet to appreciate the genuine potential of AI beyond its headline glamor.

Respondents were also asked about where AI has changed the QA skills they need. In almost every case (see Fig 06), we see that perceived skills needs are lower than in previous years, but these overall figures disguise some marked country-specific differences in the response.

Fig 06 Extent to which AI and ML change the skills needed from QA and test professionals



For instance, the greatest overall area of need this year was identified as software development engineering testing skills (S-DET), mentioned by over a third (34%) of respondents. However, in the Netherlands, it was an issue for only 5% of respondents, while in the UK, Belgium and Luxembourg, the figures were over 70%. It could be that these latter countries are genuinely lagging in this regard, or it may simply be that category has been interpreted differently in different countries and organizations.

The country-specific differences were fewer for non-functional testing skills, the bottom bar on the grid, where the global result of 19% of respondents shows a marked drop on figures for the previous two years. It could mean that organizations feel they have things pretty well covered – or they might think that AI doesn't really alter skills requirements in these areas.

Relevance of AI and ML in QA tool selection

Is AI now a key criterion for selecting new QA solutions, products or tools? Overall, 86% of our respondents said yes. This is a figure we might have expected to be higher, and once again, it is a universal figure that hides some country-specific differences. For example, only 60% of Japanese respondents agreed. Perhaps this is because Japan has a long-established history in QA practice, and has a broader range of criteria than most when it comes to tools selection. Indeed, many Japanese engineering companies have spent much time building in-house solutions for most of their tooling needs, and they are averse to changing tools with which they are familiar.

We also asked about the current usage of smart options in QA. Two-thirds of respondents (66%) said they use smart tools for the automatic design and the execution of test cases from code changes, and 56% of respondents said they use them for identifying the most important user aspects and configurations to be covered during testing. It would be

interesting to know why people gave these answers: here, as is so often the case with artificial intelligence and machine learning, the words that are used to describe applications are capable of several interpretations.

Perhaps, as time passes, and as AI and ML move beyond early excitement and into more widespread everyday acceptance, we will begin to see more meaningful usage patterns.

Looking ahead

In a similar vein, we also asked people to look ahead (Fig 07): what were their plans for AI and testing?

Of all the responses to this question, the popularity of the first statement is of course the least surprising. Almost nine out of ten respondents (88%) said that AI was now the strongest growth area of their test activities. The bottom position for test execution makes sense: current tools already address these activities very well. However, we might expect to see smart QA dashboards increase in importance in years to come. As we have just noted, it may well be the case that some QA teams are exploiting AI hype for general budget purposes – but that, we feel, will be only a small part of the picture.

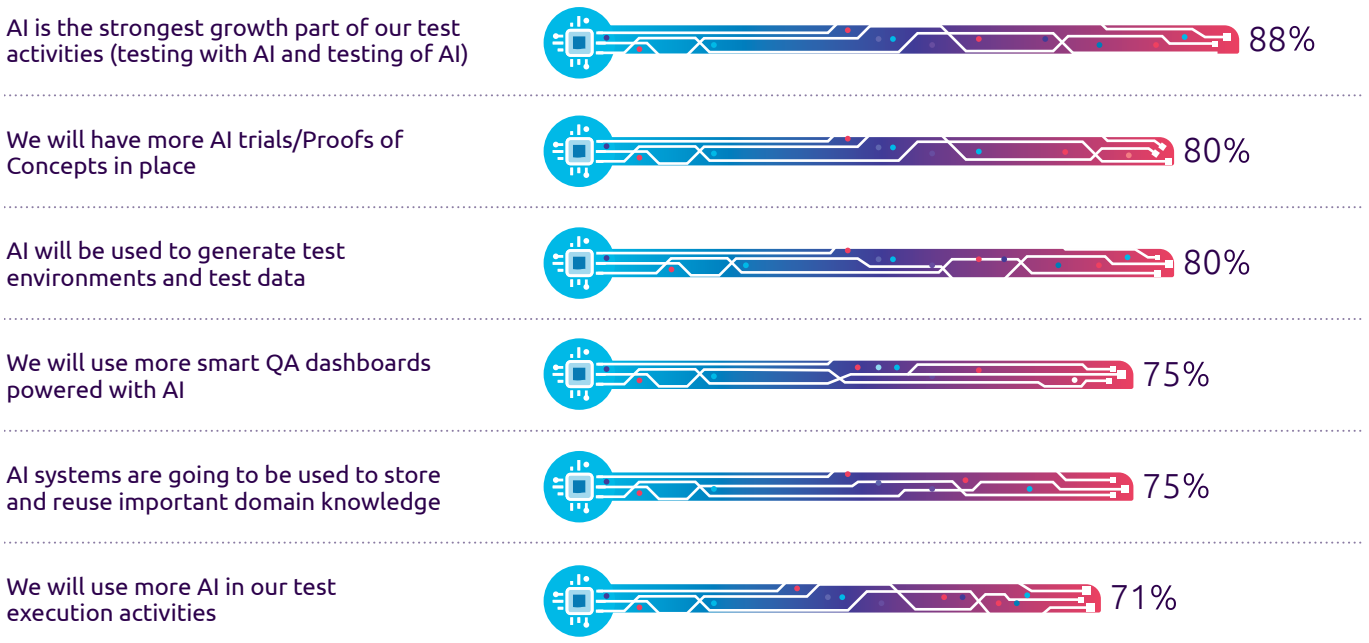
Even though the benefits may not yet be fully in reach, the vast majority of people are genuinely enthusiastic about the prospects for AI and ML. These smart technologies have real potential not just in cost-efficiency, in zero-touch testing, and in time to market, but in the most important way of all – and that is in helping to achieve continuous quality improvements.

Making AI and ML part of tools evaluation

> *"Some of the tools we use have AI built into them – in mobile and web-based testing, for instance. The AI learns the app, and adapts itself within the automated test routines."*

Leon van Niekerk
Head of Test Center of Excellence
Pick n Pay

Fig 07 To what degree the following statements reflect your plans to utilize AI in QA activities?



call to action

Artificial intelligence and machine learning

Focus on what matters.

If we were to summarize what artificial intelligence can do for digital assurance and quality engineering, it would be the ability to bring higher efficiency and faster outcome.

It's a good idea, therefore, to put these technologies in the hands of smart people, and to ask them to focus on what's important. The area of greatest need is likely to deliver the greatest benefit. What's more, any early successes won't just be good for morale: they'll also be a platform for future success.

Adopt smart ways of working.

Focus on value added activities by leveraging the insights gained through implementation of analytics, AI and ML in QA. Encourage teams to adopt the tools having AI capabilities

Look beyond conventional QA skills in the team.

Skills gaps feature in the World Quality Report every year. It demonstrates that there's always something new to learn, and in the case of AI, it's not just about what the technology can do, but about how it can be incorporated in the overall software development lifecycle.

In short, for organizations to derive the greatest benefits from AI in quality engineering, they'll need their teams to strengthen their knowledge and experience of the tools, of overall QA and IT strategy, and of the commercial objectives of the business as a whole. It's a great opportunity, not just for companies, but for the QA people they employ.

QA teams need to have few team members having data science, analytics and AI skills. If required, they should collaborate with other parts of the organization to acquire such skills.

Testing AI systems: have a strategy.

Using artificial intelligence to test is one thing. Testing AI itself is another, particularly when it's constantly evolving and becoming an integral part of your business survival. There are challenges in the holistic coverage of AI systems – for instance, bias in AI and ethical AI. This is especially the case when business solutions venture into supervised, unsupervised, natural language processing (NLP) and deep learning.

Organizations can start to approach this challenge by gauging the approach being taken in most common use cases of AI, such as self-driving cars, ride-sharing apps, or speech and face recognition software. Can any general principles be derived for testing other types of AI systems? We think yes, and this field is going to continue witnessing new innovations and strategies.

Test automation

Steady determination brings progress towards increased speed and flexibility

Archie Roboostoff
Head of Product Management, Functional and Performance Testing, Micro Focus

Parinita Patankar
Vice President, Digital Assurance and Quality Engineering, Sogeti India

Rajesh Natarajan
Director, Digital Assurance and Quality Engineering, Sogeti USA

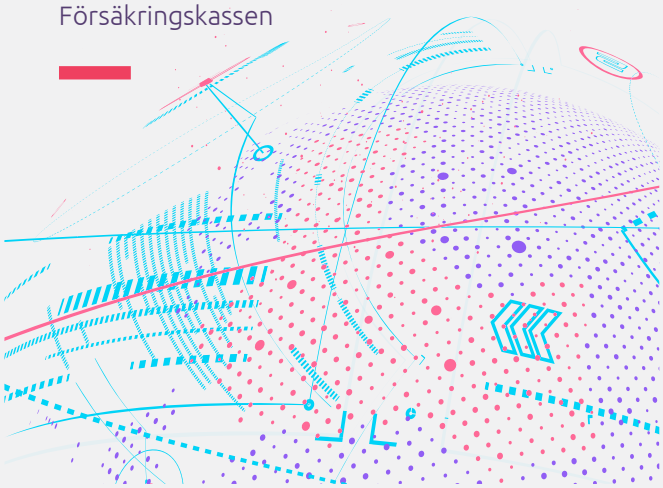
Sai Grandhi
Director, Digital Assurance and Quality Engineering, Sogeti USA

Wouter Ruigrok
Agile Quality Coach
Digital Assurance & Testing, Sogeti, NL

Tracking progress to a zero-touch future

> *"We've started to automate some of our testing, but we need to do more. We're measuring the automation levels we're achieving right across our software development function. The goal is to be as little hands-on as possible. It's going to be part of the platform: it will happen without the developer even having to think about it."*

Anders Lemon
Head of Architecture, Application infrastructure, Development Platform and Quality Process, Försäkringskassen



Test automation has become such a major area of focus in quality assurance (QA) in recent years that, before we dive into what this year's survey data tells us, it might be useful to articulate some of the trends we have recently been witnessing in the field.

We've been seeing new machine learning techniques being applied to object recognition, and also to determine the scope of optimal automation tests to reduce the exponential growth in test scripts. AI-based self-healing scripts to automatically modify scripts during run time, in case of object and page element changes, are also an interesting addition to the arsenal of new automation techniques.

We've also seen what we might term the automation of automation – for instance, automating testing within an RPA routine in order to identify the types and the relative performance of the most common transaction each day. Another good example of this is where intelligence is being brought into production, such that zero-touch automation can identify missing test cases, generate them, and run them, in a highly automated, highly intelligent, and highly targeted way.

However, it's only some organizations we see that have reached levels of maturity that are akin to all this. Many others are still feeling their way.

Re-assessing challenges

Difficulties like this are revealing, which is why it has also been interesting for us to revisit a question from the 2019 survey that was not asked this year. That question explored the challenges organizations faced in achieving their desired level of test automation, and among the most common responses, in 2019 and also in previous years, was the frequency with which applications were changing. That challenge hasn't gone away, and it is part of the reason why interest is growing in machine-based testing. We're going to

see more instances of the example provided above, where an automated process can run software, identify needs, spin out test cases, run those tests, and then report on them – all without intervention.

Another abiding challenge in previous years has been the lack of people with sufficient specialist skills and experience. It's why we see organizations having difficulty with formulating overarching strategies, and applying automation to areas such as regression testing, rather than to anything broader in scope and more ambitious.

A third of respondents last year said they had too many different automation tools. The good news is that this seems to be less the case now. It's also worth noting that with so many organizations moving to a continuous integration / continuous delivery (CI/CD) platform, it's difficult to work with only a handful of tools. What's needed here is not necessarily a smaller toolkit, but better orchestration. This, we feel, should be a goal for 2020.

Where is automation happening?

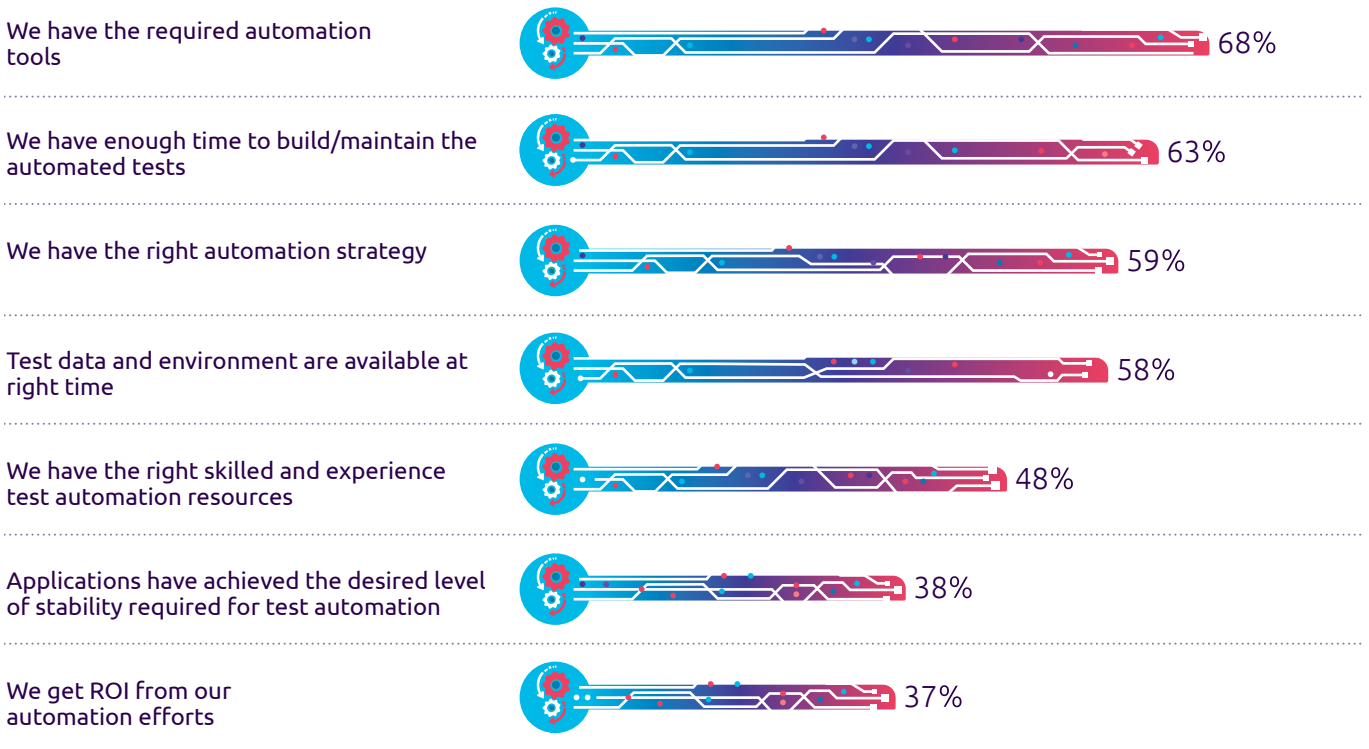
Several of these themes are corroborated by this year's survey findings. The volatility in applications – in other words, the frequency with which they change – has not gone away, and this is perhaps one reason why we see only

Balancing speed against accuracy

"Our CTO is highly focused on resilience and stability. We have zero tolerance for downtime, as does our regulator. So we invest a lot of time in production analysis, and in assessing the operational performance of our teams. There's always a balance required between quality, risk and delivery time. Test automation helps in this regard but it's about utilising the experience of our subject matter experts too."

Barry Blake
Senior Manager, QA & Testing, Permanent TSB

Fig 08 Test Automation: Level of adoption



Making automation part of the CoE toolkit

"Wherever possible, we focus on reusability in performance testing, so we need to do more R&D in this area. We may also look at introducing automation skills to the applications testing and performance testing teams in our Center of Excellence."

Tribikram Rath
Director, QA Engineering
General Electric

slight increases in the degree to which automation is being used in different areas of QA. Overall, our respondents told us that around 15% of all testing was automated. Only 3% of them said they were automating 21% or more of their test activities.

Percentages for the automation of individual test activity types have mostly risen since last year, although we would have expected them to be higher still. User acceptance and unit testing each came in at 18% (both of them were at 15% last year), and automated system integration testing and automated test data generation each came in at 17% (up from 14% each last year). A new survey option this year was API testing, and respondents told us 19% of their activities in this area were automated.

Given these percentage levels, it's perhaps surprising to see the degree of confidence organizations expressed when they were asked for their views on various aspects of test automation (see Fig 08).

Some of these views seem aspirational to us. For example, the frequency with which apps are now changing is hard to square with the 63% of respondents who say they have enough time to build and maintain their automated tests. It could demonstrate an unwillingness to admit that their teams are time-squeezed: if those team members had been asked the same question, the answers may have been different.

Our survey also indicates the willingness of the QA community to consider newer natural language processing (NLP) based automation tools, which provide key benefits such as scriptless automation, model-based testing, the use of plain English statements to generate scripts, and a shallower learning curve, which enables all project stakeholders to contribute to automation efforts. Options such as self-healing capabilities are going to increase gradually, but there is no doubt that these are the future of automation.

While the promises are big, we understand these automation tools aren't yet sufficiently mature, based on the challenges mentioned by our survey participants.

Perceived benefits…

It's also interesting to note that while as many as 68% of respondents said they have the required automation tools, only 37% of them felt they get a return on that investment. This may be because of increasing maintenance efforts that are required to maintain larger automated suites. We feel moving towards scriptless automation tools may provide better return on investment in the long term.

We asked our survey participants to consider the benefits question in a little more detail (see Fig 09). The bars on the left show the percentages of respondents who felt they were seeing those benefits, while the boxes on the right show the average value of that benefit for these respondents.

In the bars on the left, the perceived benefits for 2020 are, as we would expect, mostly higher than in previous years, although we are surprised to see fewer respondents seeing better test coverage. It is interesting that the greatest perceived benefit was better control and transparency of testing activities.

The boxes on the right indicate a lower perceived value of these benefits year on year. The reduction of test costs is a case in point. What may be behind this is the extent to which respondents are factoring in the same criteria when they consider this question. Are they each including investment in

Incorporating physical automation

"We started automating customer payment processes end-to-end in 2017. There is a physical element to this automation: for instance, we have a robotic arm that inserts into the machine reader one of the bank cards we keep for testing, and that then enters the PIN. It's an example of how we focus on front-end, functional business process testing – in other words, on what really matters to our customers."

Leon van Niekerk
Head of Test Center of Excellence
Pick n Pay

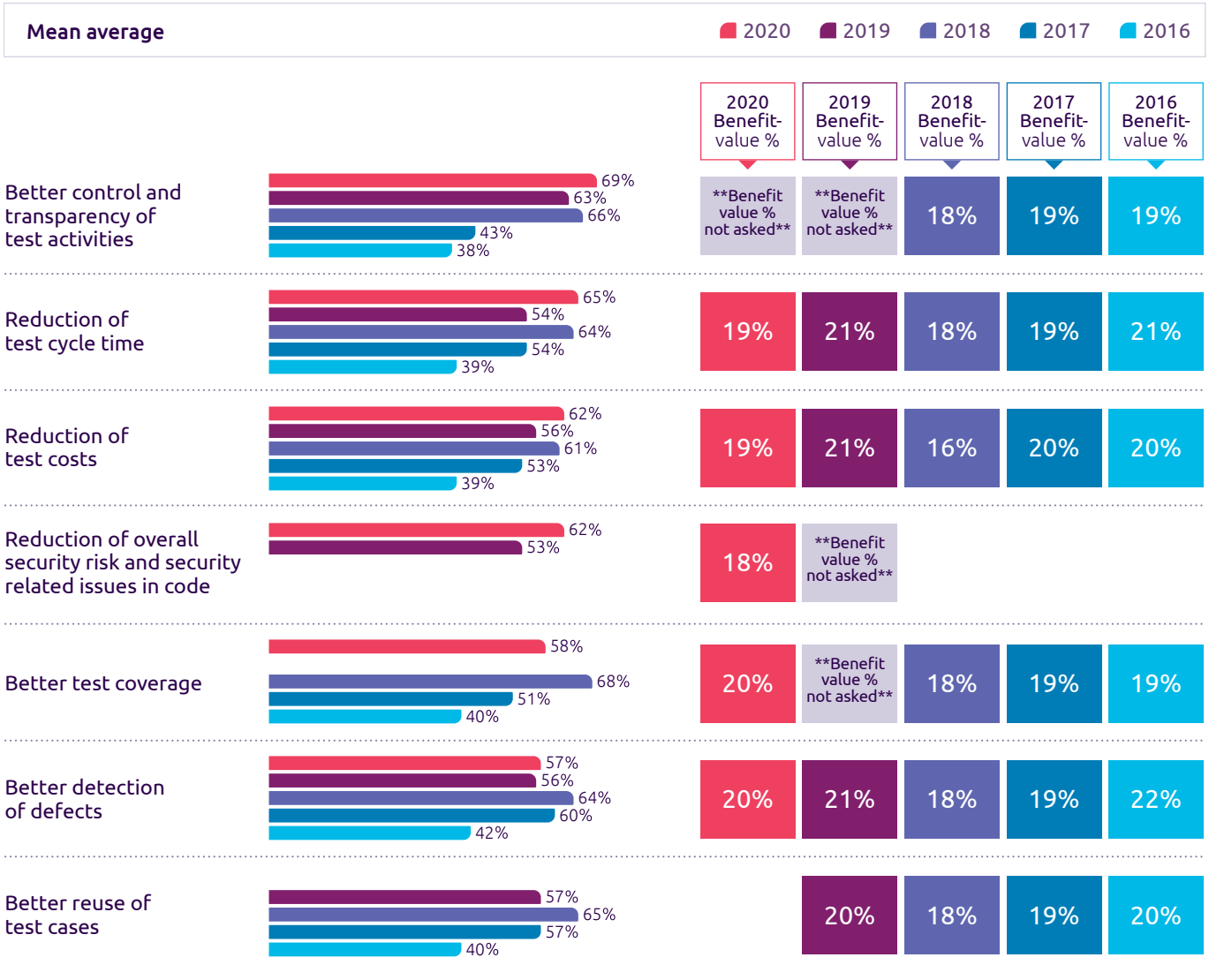
tooling, in infrastructure, in maintenance, and in building the suite, or are some of them only considering some of these?

Besides, it might be argued that test cost reduction is not as useful a metric for measuring automation benefits as, say, the reduction of test cycle times – and it's good to see a rise this year to 65% of respondents reporting this benefit, from 54% last year. It's the biggest increase on the graph.

… and perceived skills needs

The perceived presence of the requisite test automation skills is always interesting, and this year we see skills needs dropping year on year in several categories, including development skills (down to 41% from 51% last year), and test automation architecture skills (down to 30% from 38% last year). Robotic process automation (RPA) skills were also down, to 35% from 43%, which we found surprising – but overall, we feel these drops can be explained not by the fact that skills gaps are shrinking, but by the presence among the responses of a CI-CD skills option for the first time this year, which may have skewed the figures. The CI-CD approach is a hot topic right now, but strengths in this area are not really needed by the whole team. Team members would more broadly benefit from skills in other areas, including development, machine learning, and API and microservices.

Fig 09 Benefits realized from test automation



Looking ahead

In conclusion, we asked survey respondents to look ahead, and to rate the automation techniques they would be extremely likely to use in the year to come (see Fig 10). The greatest response was for test environment virtualization at 16%, while model-based testing, which was the highest rated last year, has dropped from 17% to 9%. In our experience, few companies have any kind of uptick in this area, partly because there are significant set-up and management overheads.

Like last year, test design automation came at the bottom end of the results. It's dropped even further this time, though, with only 5% of respondents saying they will be extremely likely to use it in the coming year, against 8% last year. This, we feel, may be a good sign. It could be an indication that measures in this area are already in place.

Taking stock, we feel that positive progress is being made here overall. Organizations are working their way forwards, in spite of the increasing complexity of applications, devices, and browsers.

We feel that the tools are getting smarter – and that people need to be sufficiently skilled to get the most out of them.

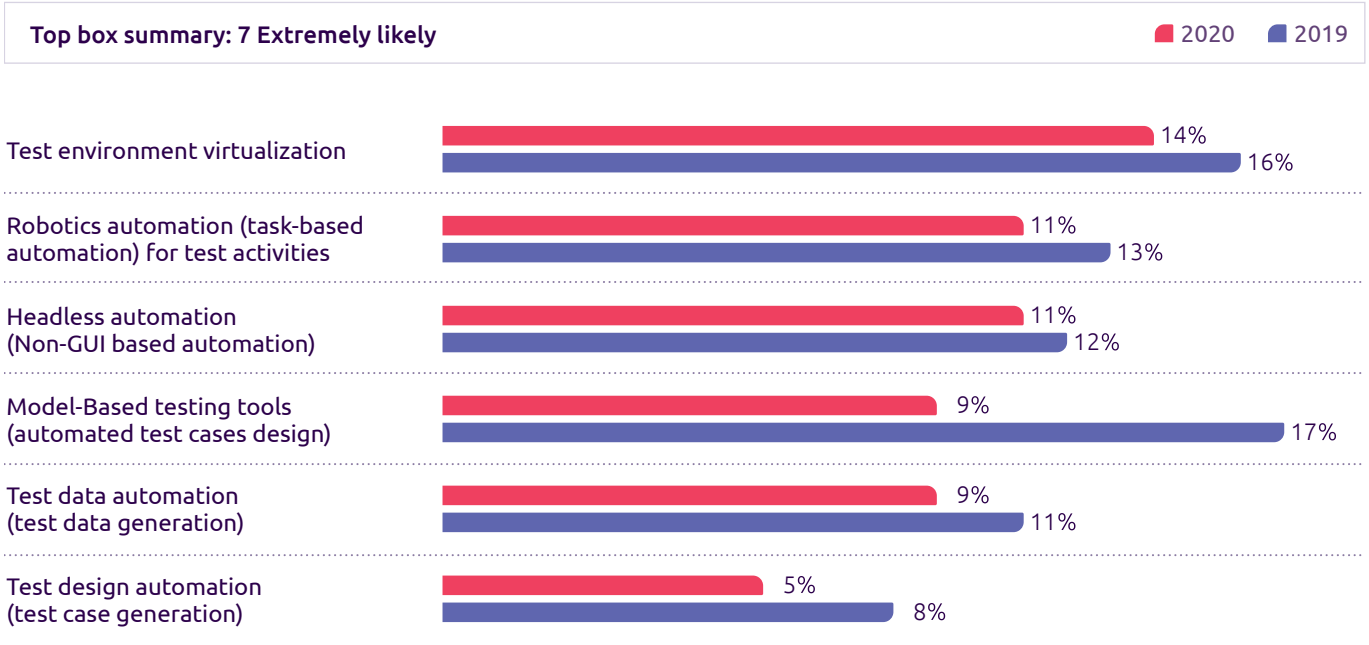
Last of all, it's worth noting that technological innovations in general are a means to an end. They are not an end in themselves, and test automation is no different in this respect. It has a job to do – and that job is to bring new levels of speed and flexibility to quality assurance.

Moving automation into mainstream QA

"Over the next two or three years, I think we're going to see automation play a greater role – artificial intelligence and DevOps, too. Already, we're seeing more in-sprint automation, earlier in the development cycle, so issues are being identified earlier, and faster, too. This helps to create better quality metrics."

Suvo Ghatak
Senior Manager
Quality Engineering, Wabtec

Fig 10 How likely you are to use the following techniques in the coming year?



Test automation
call to action

Change the status quo.

We need to accept that for various reasons, the testing phase will continue to be squeezed. Introducing more automation – and pursuing it vigorously – is the only way out of this evergreen challenge.

Think ahead.

Modern applications to which test automation might be applied will continue to undergo rapid changes. That's why choosing a tool or framework that will keep pace with dynamic changes is very important.

Choose the right framework.

Opt for design automation frameworks that are intuitive, dynamic, that have self-spinning environments, that have algorithm-based prioritized scoping, and that can self-provision test data.

Balance automation against skills needs.

Gaps between advanced automation tools and required skillsets are here to stay. The way forward is to develop a strategy either to lessen dependency on skills or to make automation inclusive.

Get smart.

Offload the technical challenges in automation for artificial intelligence and machine learning to take care of.

Test data management and test environment management

Kirthy Chennaian
IT Transformation Director
Digital Assurance and
Quality Engineering
Capgemini North America

Ramesh Mahadevan
Senior Director
Digital Assurance and
Quality Engineering, Sogeti India

Kyle Abraham
Regional Practice Leader,
Digital Assurance and
Quality Engineering, Sogeti USA

Slow but steady progress in the complex world of test data and test environment

Focus is on efficiency and quality

"We have created a QA enablers team that focuses on test environments, test data, tooling and service virtualization. Bringing this QA enablers team closer to the test execution has resulted in improved efficiency and quality."

Andy Armstrong
Head of Quality Assurance & Testing
Nordea Bank

Some things in business take a long time to change, and in quality assurance (QA), many of the challenges we saw last year in the field of test data management (TDM) and test environment management (TEM) are just as much in evidence this year.

Organizations still need to figure out the best way to spin up test data and test environments on demand. While adoption of cloud and tool usage has shown a positive trend for TEM and TDM, more maturity is needed to make effective use of the benefits of the cloud and of TDM tools. The overall governance of test environment and test data came out as a bigger challenge than the technology itself. The holy grail of test environment and test data is to strike the right balance between the cost and the timely availability of the fit-for-purpose environment and data. These challenges are further exacerbated as teams adopt an automation-first, continuous testing approach to QA. Integrating with diverse systems, including third-party systems, to simulate real scenarios and orchestrate end-to-end, continuous testing remains a challenging endeavor.

Addressing these challenges is far from straightforward. It requires an organization to undertake a long, well planned journey. The good news is that we see several organizations ready with a roadmap, and making steady progress.

Evolution, not revolution

In our survey, we asked respondents about the extent to which they are using different types of test environment (see Fig 11), and we see that 29% of testing still occurs in a traditional on-premises test environment.

However, it is worth noting a few things:

- The proportion of survey participants using a traditional approach has been slowly declining for the last two years.
- The proportion using cloud-based, on-demand disposable test environments has been increasing over the same period.
- There has also been an increase since last year of testing in containerized environments, using Docker or a similar technology.

While the changes indicated here are small, two points are worth making. The first is that, in our experience, while differences may be incremental, some organizations are building real momentum in the move to the cloud and in using virtualized environment and data.

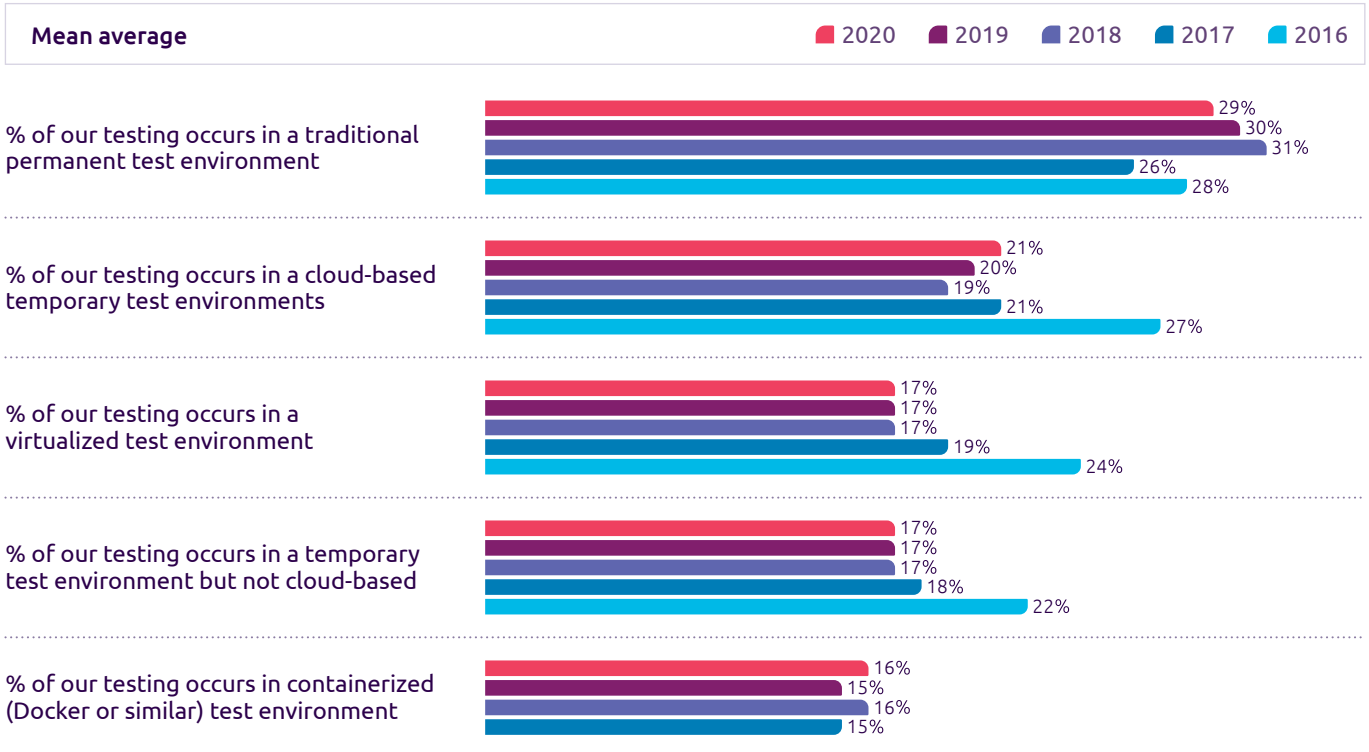
The second point is that the general pace of change is likely to accelerate. The new business environment precipitated by COVID-19 has created a genuine sense of urgency about achieving digital transformation, and one of the many beneficiaries of this new impetus is likely to be TEM. This is a trend worth watching, and we anticipate real change over the next couple of years.

Effective QA is integral to digital transformation

"As part of our overall push towards digital transformation, we expect our test environments to move from the data center to the cloud."

Tribikram Rath
Director, QA Engineering
General Electric

Fig 11 Percentage of testing occurring in various test environment types



Achieving benefits with TEM and TDM

How comfortable were organizations about their QA teams' ability to succeed in achieving targets related to test environments? High levels of satisfaction were reported for the robust configuration of test environments (49% of respondents); for the timely availability of the right test environments (47%); and for the modernization of test environments, for example with the cloud and containers (also 47%).

These technology-related responses scored higher than those related to governance – for instance, sufficient facilities for teams to book and manage their test environments (33%), and good visibility of available test environments (29%). But on the whole, these figures aren't too bad – and the timely availability figure of 47% is a marked improvement on last year's response. We think that IT teams need to do more to maximize the benefit from the cloud. While organizations have moved in this direction, the right governance is lacking in many cases. For example, we witnessed that the environment is not released in a timely manner when it is not needed, thereby resulting in a higher cost.

On the TDM front, we were little surprised at the satisfaction score with teams' ability to deliver benefits. As many as 61% of respondents said their teams are able to manage the size and complexity of test data sets. While this looks good, we think that several respondents still equate test data with copying and masking the production data. With continuous testing and a push for more performance and security, that in itself may not be sufficient. Also, if we compare this with last year's survey, we see that some of the challenges didn't come out that strongly this year, such as the ability to manage test data consistency across several disparate systems. So, based on our experience with several customers, and also making comparisons with past surveys, we think that while progress is being made related to TDM, the desired maturity will take more time to realize.

That said, well over half of our survey participants (58%) said their teams create and maintain synthetic test data for testing, and we do indeed see this ourselves in the field.

The proportion of respondents who claimed to provision and generate test data for multiple iterations of testing in various ways was interesting. As many as 90% of them said they maintain specifically created test data sets for their tests. It's true that in some industries – healthcare, for instance – there are very stringent data requirements, but this figure seemed high to us, even though the trend is indeed in this direction.

Even more surprising was how many survey participants said they create test data manually with each run. Here, the figure was 79% – a big jump up from 59% and 58% in the previous two years. We suspect that this year, respondents have taken "manually" to mean test data that has been generated by the team, rather than being derived from production data – but even so, it's a very high figure. We suspect teams are creating specific test data sets in large volume to address the needs of continuous automation and performance. The complexity of testing has increased. Adapted TDM solutions partially solve the problem since we observed that clients buy TDM tools to mask production data. Masked production data doesn't provide testers or developers the breadth of the volume of test data needs.

Centers of excellence can catalyze innovation

"We're continuously innovating on TEM and TDM. We have a center of excellence in place that assesses priorities, oversees and directs processes, and implements the right tools for TEM and TDM."

Hemant Anugonda
Assistant Vice President
TMNAS

Test environment monitoring

Organizations are using different approaches to identify environment-related issues encountered during testing. The figures weren't especially high, but they were interesting: 38% said they use infrastructure monitoring to notify the test environment server level outage; 32% said they have effective test environment monitoring solutions, enabling outage notifications, trend analysis and self-healing features for all test environments; and 27% said they have detailed environment monitoring enabled only for higher test environments, such as acceptance tests, or integration tests.

This shows that only about one third of the enterprises have adopted a mature approach towards test environment monitoring and management. However, enterprises are still not using monitoring tools on test environments to compare and contrast that of production to ensure that both environment configuration and performance issues are correctly addressed.

Agile and test data provisioning

How are organizations provisioning and generating test data for multiple iterations of testing, and to what extent are they using each approach? In fact (see Fig 12), the range and extent of responses were fairly evenly matched. This question was updated to include new answer options this year, which invalidates trend comparisons with previous reports. It will be interesting to see if there is any movement here in years to come.

Finally, in a new question for this year, we asked our survey participants to rate how frequently various test data provisioning approaches are being used in their agile teams, and the graph opposite (see Fig 13) shows their highest responses. Almost two-thirds (64%) of them said they use a dedicated test data support team on an as-a-Service basis. This is to be expected: as organizations move toward agile, TEM and TDM are indeed likely to become more of a shared service function, serving multiple and distinct agile teams.

We also note the extent to which teams are creating small, dedicated test data sets for each sprint (39%), and the degree to which they are generating bulk data sets that are re-used for every sprint (31%). These approaches are becoming more popular in certain sectors such as healthcare, and we expect to see these numbers grow.

Fig 12 Provisioning and generating test data for multiple iterations of testing

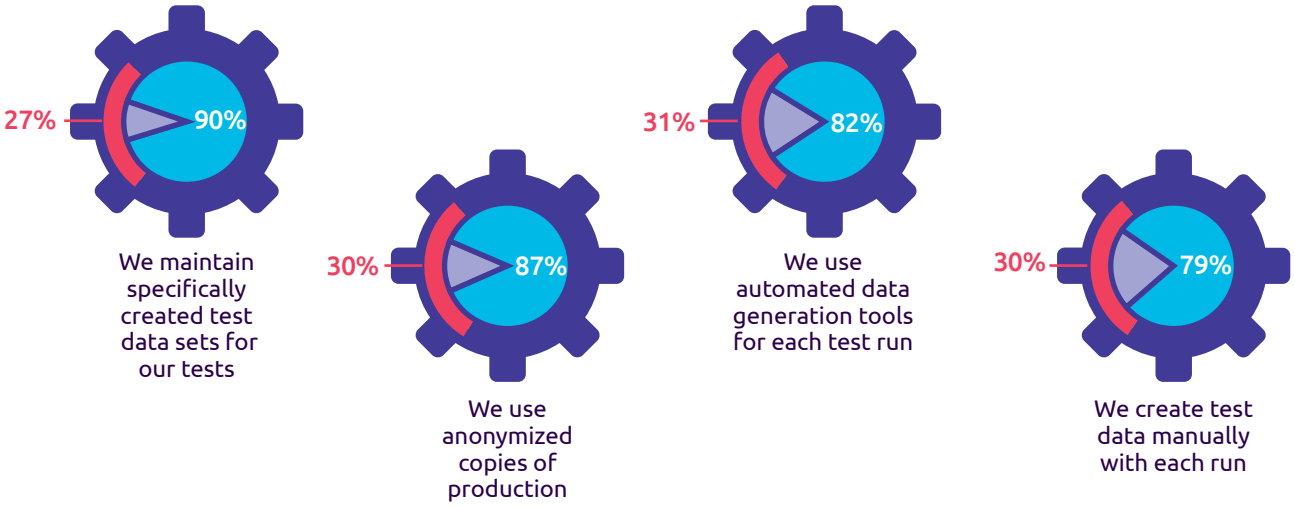
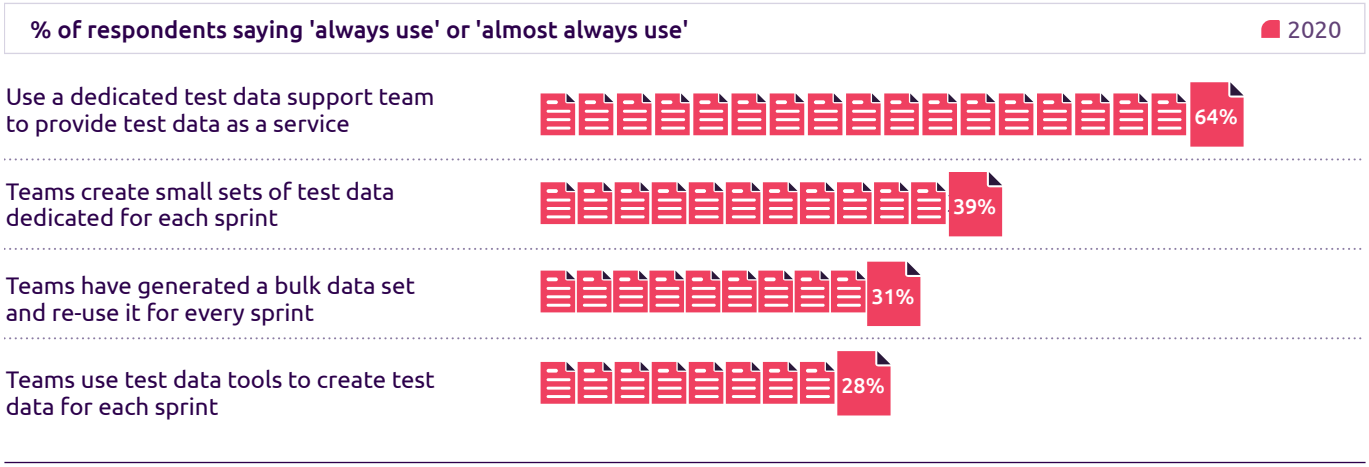


Fig 13 How frequently the following test data provisions are used by agile test teams?



Summary

It's clear to us – not just from this year's survey responses, but also from our collective experience – that TDM and TEM still represent a highly complex space. Test environments are still in a hybrid form and are evolving slowly. We're seeing some clients adapting TDM solutions and TEM monitoring, but we have yet to see how their adaption is fully benefiting the quality of their test data or test environment.

We can also be cautiously positive about progress on test data management. There are plenty of expensive TDM tools out there, but they are not silver bullets; and also, organizations are still learning how best to take advantage of them so their benefits can be fully felt. For instance, some organizations use such tools simply to mask the production data, when they could instead be used to create test data sets with infinite permutations to help business leaders, developers, and testers in the design and test of business rules.

One last point. Many QA teams think of TEM and TDM as two distinct problems. For instance, they might seek to solve TEM by moving it to the cloud, but their TDM is still a mess. In our view, the transition to the cloud offers a great opportunity to build the test data management strategy so as to get the best possible return on their investment.

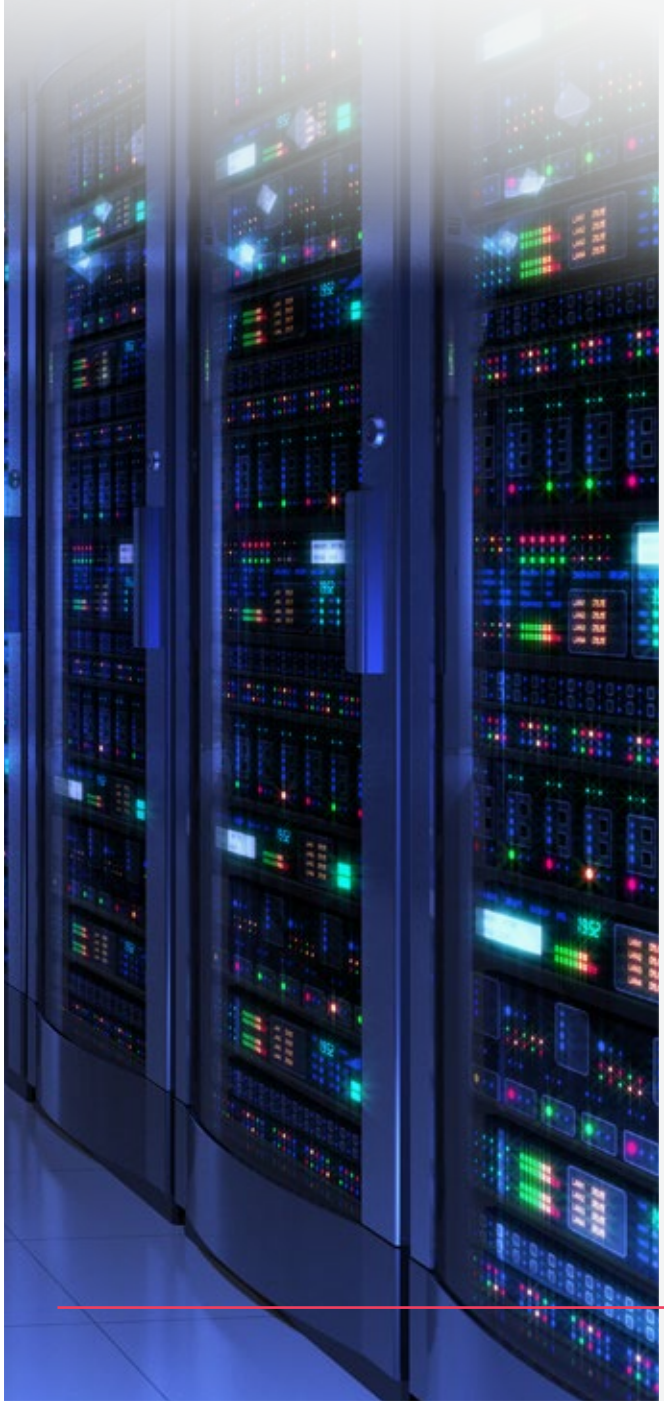
Cloud-based environments increase availability

"Over the next two years, I expect to see test environments become completely cloud-based. Access will be via one click, and they will always be available."

Suresh Dwadasi
Delivery Head, multinational bank

TDM & TEM

call to action



Create a shared center of excellence for TEM/TDM.

A shared center of excellence (CoE) should be created to service the TEM and TDM requirements within an organization. This team should create a strategic framework which each of the project teams can use. The team should define governance and the process, the TEM hosting strategy, and the tools strategy. Depending on the specific organization dynamics, this team can either service all the TEM and TDM requirements, or it could be de-centralized. But, if maturity is low, we suggest starting with a centralized approach.

Get as much value as you can out of your tool investment.

There have been significant enhancements of TDM and TEM tool capabilities, but there are very few teams that are realizing their full potential. We suggest that concentrated effort is made to plan and implement the various features that these tools provide, to train the team members, and to measure and report regularly on the benefits.

Have strong governance in place.

It's essential to have a mature approach to the governance of managing the complete lifecycle, from raising the demand to de-commissioning and archiving the test environment and test data. The QA teams should jointly work with the TEM and TDM center of excellence to forecast demand and achieve visibility of what is available. It should be able to use the available resources with ease.

Budgets and cost containment

Managing QA budgets in challenging times

Chaitanya Joshi
Director, Financial Services
Digital Assurance and
Quality Engineering, Capgemini UK

Hitesh Patel
Regional Practice Leader
Digital Assurance and
Quality Engineering, Sogeti USA

Jeba Abraham
Regional Practice Leader
Digital Assurance and
Quality Engineering, Sogeti USA

Shiva Balasubramanian
Vice President, Financial Services
Digital Assurance and
Quality Engineering, USA

Continuous testing pays dividends

"Quality is imperative to the bank, and to its customers and regulator, which is why we focus on consistently high quality across everything we do. As part of this, we're now building testing back into the very early phases of design and development, and we're taking it all the way through implementation and post-production too."

Barry Blake
Senior Manager, QA & Testing,
Permanent TSB

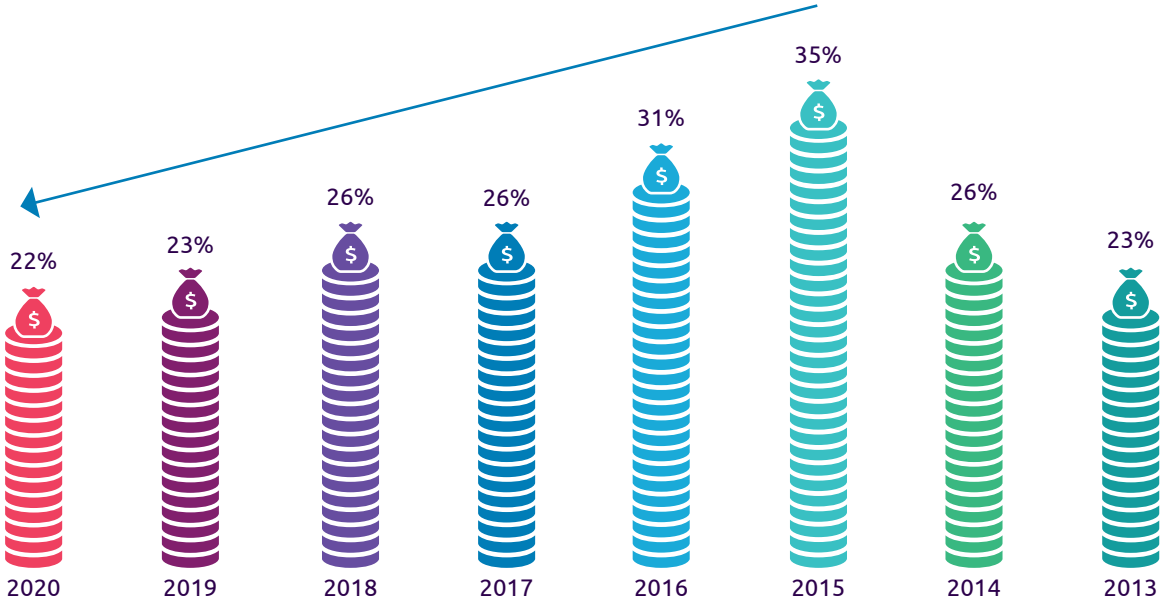
When Benjamin Franklin said, "In this world nothing can be said to be certain, except death and taxes," he should have added budget control to the list.

The certainty of it was true then, and it's true now. It's especially true for a modern business. Successful organizations focus on being more efficient by doing more with less, rather than cutting down on their key initiatives and saving money. However, situations such as this year's COVID-19 pandemic have resulted in even more focus on budget control. IT budgets have seen tighter scrutiny, and this has had a cascading effect on the quality assurance (QA) budgets.

There has been greater emphasis on being more efficient as the digital business grows rapidly, especially in retail, e-commerce, media and entertainment, and healthcare. New platforming such as CRM, ERP, and native cloud and mobile app development in these sectors has meant that QA teams have to do more.

At the same time, new initiatives are being put on hold in several sectors. The twin effect of being more efficient and of cutting down on new initiatives has been to reduce IT spend, and QA budgets have been proportionally impacted.

Fig 14 Percentage of IT budget allocated to QA activities



Responding to the challenge – learning from best practice

Smarter organizations have continued to invest in new products and services, and in the QA function that goes with them. Digital banking startups are a case in point, and traditional banks, recognizing this threat, have followed suit. These organizations are investing more in their QA and engineering transformation programs in order to increase efficiency, improve their upstream product quality, and accelerate their time to market.

Some of the cost containment measures we have seen in the field include the adoption of open source tools or more efficient usage of the commercial tools; increased cloud adoption, to help with streamlining environment challenges; and the application of AI and ML-based techniques to make QA more efficient.

We have also seen a focus on the end-to-end automation of critical business process testing, although a significant investment of time and effort is needed in this case to make it work seamlessly across disparate platforms.

However, others have been caught on the wrong foot by the crisis, notably the organizations that are still at a low maturity with respect to their digital transformation. For example, we heard how some insurance companies, who had not yet implemented digital transformation measures when lockdown began, were unable to do claim processing because their workforce wasn't physically able to process it.

Skills: benefiting from breadth

"We're seeing an evolution in the skill sets of our testers. We say they're becoming T-shaped: they have a broad competence in coding and testing, but they also have skills in the specifics of the development area of which they are part. The goal for us is that they must be able to perform in various tasks."

Anders Lemon
Head of Architecture
Application infrastructure,
Development Platform and Quality Process
Försäkringskassen

Centralized testing function helps in increasing efficiency

"The testing resources we've embedded in development teams can sometimes be overloaded, so our centralized testing function can provide more bandwidth. Automation can help greatly in this respect, too, of course. The extent to which it's used varies by product – I'd say from 40% all the way up to 80%. Some of it is full automation, and some of it is at what might be termed an assistance level – but even on this reduced basis, it increases efficiency and saves a great deal of time."

Chris Trimper
Enterprise Test Automation Architect,
Independent Health

The boundaries are blurring

"It's more difficult these days to track the movement of QA budgets specifically as an individual component. This is because the budget supports the overall team: the boundaries are blurring, and there is less delineation between different activities performed and the people who perform them in the agile environment."

Andy Armstrong
Head of Quality Assurance & Testing
Nordea Bank

Budget breakdown – and efficiency considerations

Every year, we ask organizations to estimate the proportion of their total IT budget that is allocated to testing and QA – and the downward trend that has continued in this year's responses too (see Fig 14). However, we also need to factor in the effect of COVID-19. It's likely that, while overall budgets are down because of the pandemic, the testing and QA budget has actually flattened out this year.

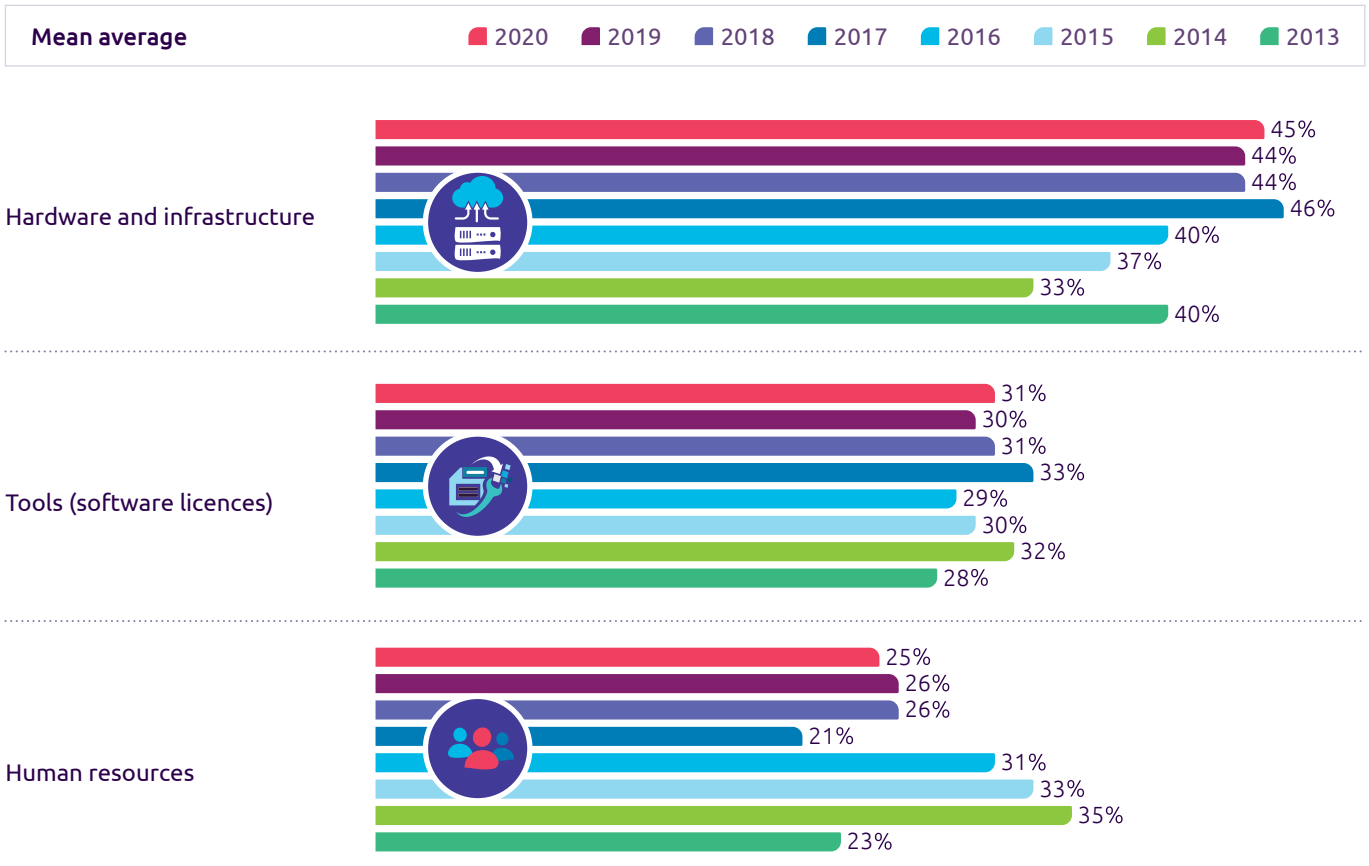
As in previous years, we asked the respondents how much QA budget is spent on hardware and infrastructure, on software tools, and on QA staffing, and how the budgets are moving overall in each of these three areas (see Fig 15). The proportion of budget allocation hasn't changed much, with hardware and infrastructure taking almost 45% of the QA cost, followed by software tools, leaving about a quarter of the budget being spent on QA staffing. However, we see greater emphasis being placed on reducing the human resources budget rather than the hardware and infrastructure budget.

Cost-cutting in QA can be risky

"COVID has significantly increased our online business. I expect to see an increase in our budgets for performance testing and for security testing."

Leon van Niekerk
Head of Test Center of Excellence, Pick n Pay

Fig 15 Breakdown of QA budget

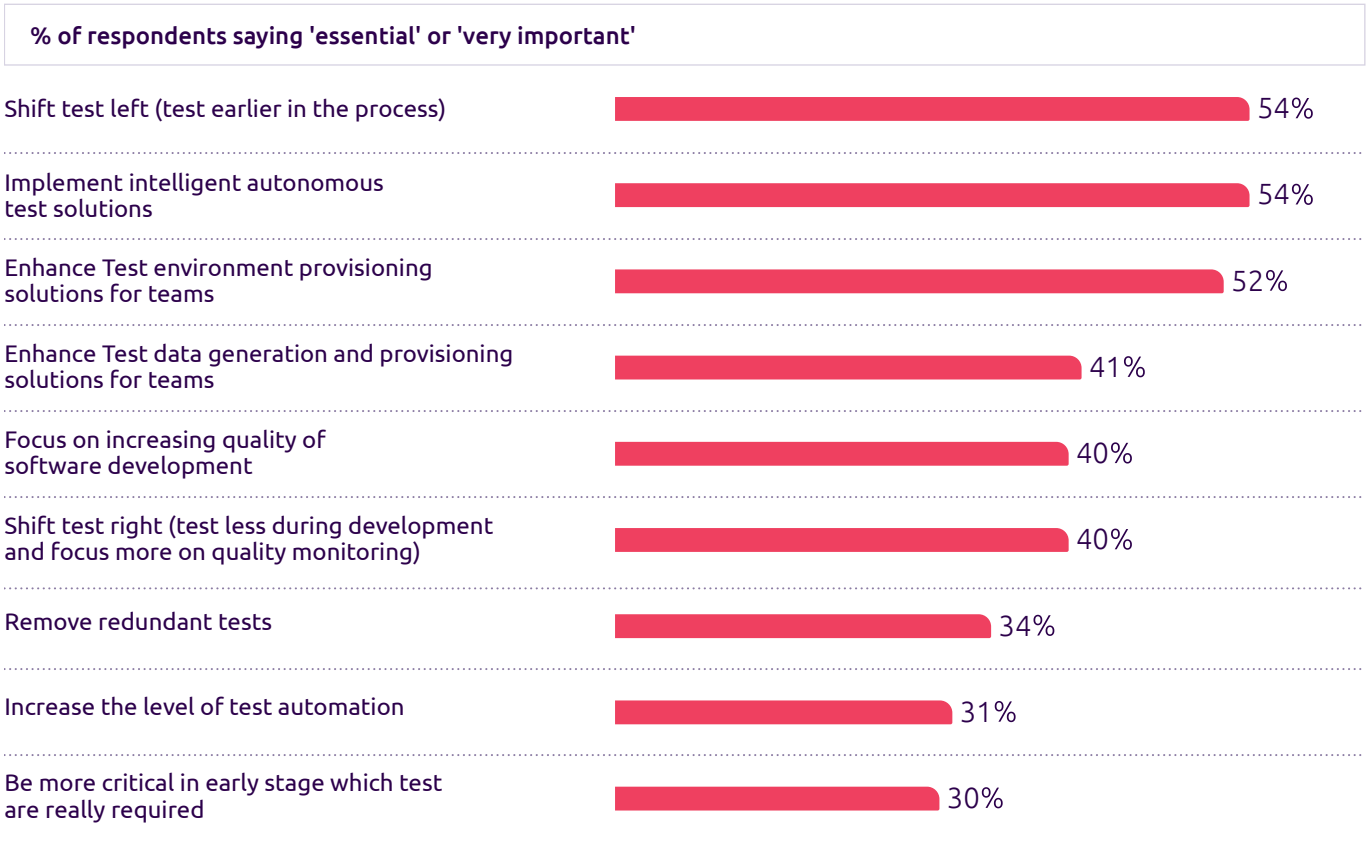


In a new question this year, we asked organizations to rate the importance of different aspects of potential testing efficiency (see Fig 16). The high levels of emphasis given to shift-left testing, to intelligent autonomous solutions, and to the enhanced provision of test environments and test data, are all consistent with what we have observed in the field.

Summary

The QA budget continues to be flat, with a slight downward bias. COVID-19 has put further pressure on IT budgets in general, and QA budgets are not immune. At the same time, the proportionate allocation between key cost components of the IT budget hasn't changed much. A large portion

Fig 16 Mechanisms used to make testing more efficient



Blurring boundaries

As we have seen in previous years with the high adoption of DevOps, the boundaries between development, QA, and operations are blurring. There are instances where in-sprint functional testing is being done by the developers, and only the specialized testing such as performance testing, or security testing is conducted by dedicated QA teams. There is a trend towards keeping a dedicated shared team for activities such as test environment management, test data management, common framework and re-usable component creation. So, while the dedicated QA budget may show a downward trend, it's difficult to ascertain how much of that budget is now consumed by the developers doing the testing.

continues to be spent on test infrastructure and tools.

At the same time, the pace of digital transformation has accelerated, and that has made quality even more important. Smarter organizations are using this opportunity to bring in higher efficiency in their QA practices. Also, while it is difficult now to measure the QA budget exactly, because of the blurring boundaries between development, QA, and operations, the good thing is that this blurring constitutes a recognition that the principle of quality is not an afterthought. It's absolutely integral to every part of the software development process.

call to action

Budgets and cost containment

Greater savings can be achieved by using test infrastructure smartly.

Maturity and adoption of cloud-based technologies, whether these are using cloud as infrastructure, or virtualization, or software-as-a-service, provide an excellent opportunity for organizations to optimize their test environment and test tool licensing costs. Organizations should make an effort to have right skilled team members focusing on optimal utilization of these resources to stay within budget.

Use advances in analytics, AI and ML to make testing smarter.

Organizations should have a solid plan in place to improve the efficiency and effectiveness of QA using advances in analytics, AI, and ML. We have seen several use cases maturing over last year in this area. For example, risk-based testing based on AI rather than on the domain experience of a tester has the potential to make testing faster and less of an effort.

Similarly, rather than taking a brute force approach to automation and spending money in automating 100% of a regression test, it is more prudent first to optimize the regression suite, and then automate the high impact test cases. Hence, it would be good to plan investment in this area up front, so as to realize future cost savings in addition to the time-to-market benefits.

Focus on quality not cost when it comes to having right skilled QA teams.

Organizations are moving towards quality assurance as an integral part of the software development lifecycle, and this requires testers to have development skills in addition to having good domain knowledge. Traditionally the costs associated with testing skills have been lower than those for development skills. But now there is an increasing need for full-stack software development engineers in test, this needs to change. Hiring people or outsourcing QA on price rather than on quality is a false economy.

Don't put key initiatives on hold. Strive to be more efficient instead.

When times are tough – and for many businesses, that's especially the case this year – the temptation to shelve new projects is strong.

It may not be economically viable to do everything that was planned pre-COVID, but it's still important not to hold back on transformation initiatives with sustainable long-term returns. If you stand still, you may as well be moving backward.

The impact of COVID-19 and its implications on quality assurance activities in a post-pandemic world

Dhiraj Sinha
Vice President Financial Services
Digital Assurance and
Quality Engineering, APAC Region

Manish Goyal
Program Manager
Digital Assurance and
Quality Engineering, Capgemini Group

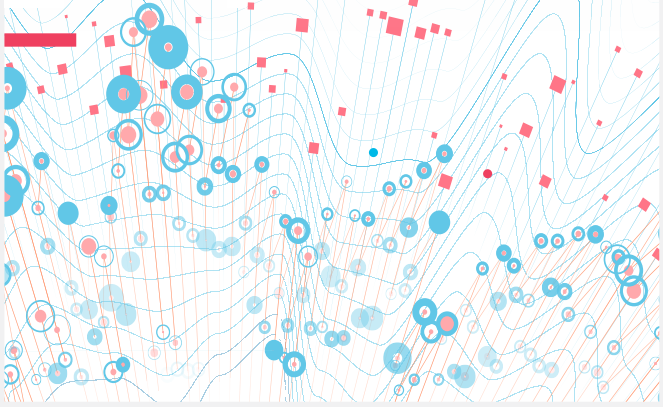
Sathish Natarajan
Group Vice President
Head of Digital Assurance and
Quality Engineering
Capgemini North America

QA teams and the pandemic: strong in will to strive, to seek, to find, and not to yield

Agile working provides a solid foundation in tough times

"We were lucky to adopt agile practices early on, and they lend themselves as much to remote working as they do to conventional environments, which really helped when lockdown came. It helped to fortify a lot of future successes."

Chris Trimper
Enterprise Test Automation Architect
Independent Health



The World Quality Report has always asked some forward-looking questions – but this time last year, no one could have predicted that in this latest edition, we would be devoting a chapter to the effects of COVID-19 on testing and quality assurance (QA).

It's not just about the effects of one on the other. It's also about the parallels between the pandemic and the discipline of quality assurance. The similarities are really quite striking. In both cases, we can see the importance of:

- The very principle of testing
- Testing early
- Automating testing, in order to achieve scale
- Adopting a test strategy that is risk-based
- Prioritizing in line with category-based needs, whether that be population demographics or lines of business.

Changes of direction – and changes by degree

The changes brought by the pandemic vary substantially by industry segment. Some sectors have been impacted more due to their legacy working practices. For instance, several organizations in the manufacturing sector and in the financial services have been slow to move to cloud-based environments, which has made it difficult for them to maintain business operations while working from home. Also, many industry sectors had to change their business model almost overnight, such as major retailers whose business was

Flexible working is here to stay…

"As we emerge from lockdown, I think working from home is going to be a big part of the new normal. We've already shown ourselves it can work. I imagine we're only going to be having people in the building at something like 25% to 30% of previous capacities, and they'll be given access in groups, on a roster basis."

Geoff Meyer
Validation Architect, Dell EMC

… and it's productive.

"We've found working from home has been very productive, both for the company and for the team. People are saving on their commute times, and they can also work flexibly – taking time out in the afternoon, for instance, and making it up in the evenings. They only come into the office if they want to, and we've put measures in place for everyone there.

We've seen an increase in the use of online collaboration tools such as Microsoft Teams. It's worked really well for us."

Suvo Ghatak
Senior Manager, Quality Engineering
Wabtec

built on an in-store experience, and who have had to move to online sales simply in order to keep going.

In other ways, however, things have changed not so much in nature, as by degree. For example, working from home has accelerated the adoption of distributed agile, thereby increasing the need for collaboration tools. This new working environment has also highlighted the need to achieve a comprehensive perspective, with real-time status monitoring and reporting in order to provide better visibility of QA activities.

We're also seeing more crowd testing: the pressure of circumstances is making it more acceptable. We're seeing greater need and use of data masking services. And we are, of course, seeing greater pressures on costs, especially in large enterprises, even though some overheads such as office energy costs and business travel costs have been lower. The pandemic has made commercial prospects harder to predict – even for just one or two quarters ahead – and this has made it hard to budget, not just for QA, but for IT as a whole. It explains why we have seen increased interest in external service provision.

Changes of focus

Our survey responses give us additional and quantitative insight. We asked VPs of applications and QA/testing managers how they expected their focus to change in testing and quality assurance post-pandemic (see Fig 17). Almost half (47%) of them predictably said there would be significantly greater focus on customer experience validation and on usability testing. This is certainly more relevant for any business moving from a business-to-business (B2B) model to business-to-consumer (B2C) or to B2B2C. Accelerated digital transformation is emerging clearly as an unintended consequence of the COVID-19 pandemic.

One of the greatest areas of impact of COVID-19 has been on the supply chain. If ever an enterprise needed a supply chain management system that was fast, flexible, and comprehensive, that time is now – which is why we're seeing even more intensive activity in digital transformation programs in general, and in the transition to enterprise solutions such as SAP S/4 HANA in particular.

Also, as expected, a high number (43%) of respondents said that the focus on more and better collaboration tools will go up, and over a third (34%) said they will need more remote access to test systems and test environments. While collaboration tools were useful just a few months ago too, they're absolutely vital now. Usage has spiked: for instance, during the pandemic, Microsoft Teams grew by 894% during a week in June, compared with its base usage in a week in February. Organizations now need to ensure that their application of these tools will continue to be robust at scale.

Fig 17 How has your focus changed towards QA activities to meet the challenges caused by COVID-19?

Security...

There have also been COVID-19-related QA implications in the area of security. While the nature of security issues as far as consumers are concerned hasn't changed, the scale certainly has. The incidents of data breach have gone up significantly as organizations have shifted to remote operations. In some ways, as more transactions and work happen online, the risk of cybercriminals launching sophisticated attacks proportionately increases.

This, perhaps, is why 83% of CIOs and IT directors have told us their application security concerns have increased over the last 12 months. It's why we now see a higher demand for security testing.

... and budgets

CIOs and IT directors also anticipate budgetary consequences. They reported an expected 13% average drop in post-pandemic testing and QA budgets.

This cut may turn out to be a short-term, reactive measure, though. While COVID-19 has indeed put pressure on costs, it has also put more of people's lives online, which can only mean that the need for robust quality assurance and data security will increase. Current circumstances present QA teams with the opportunity to make a strong case for greater funding.

The post-pandemic QA landscape

Has the pandemic changed perceived quality goals? It would seem so: more than half (52%) of our respondents said that those goals had changed a great deal, or that they needed a major overhaul.

The watchwords for QA have always been speed, quality, and cost, and the trade-offs between them are ever-present. As business begins to emerge from the pandemic, these goals will need to be reassessed for every individual system and application test project.

There is certainly great determination to use the upheavals of 2020 as an opportunity to make positive changes in practice and in mindset as far as quality assurance is concerned (see Fig 18). Even the lowest-rated statement in the graph shows that almost three-quarters (74%) of respondents said more automation is needed, and the other four featured statements are at 80% or higher.

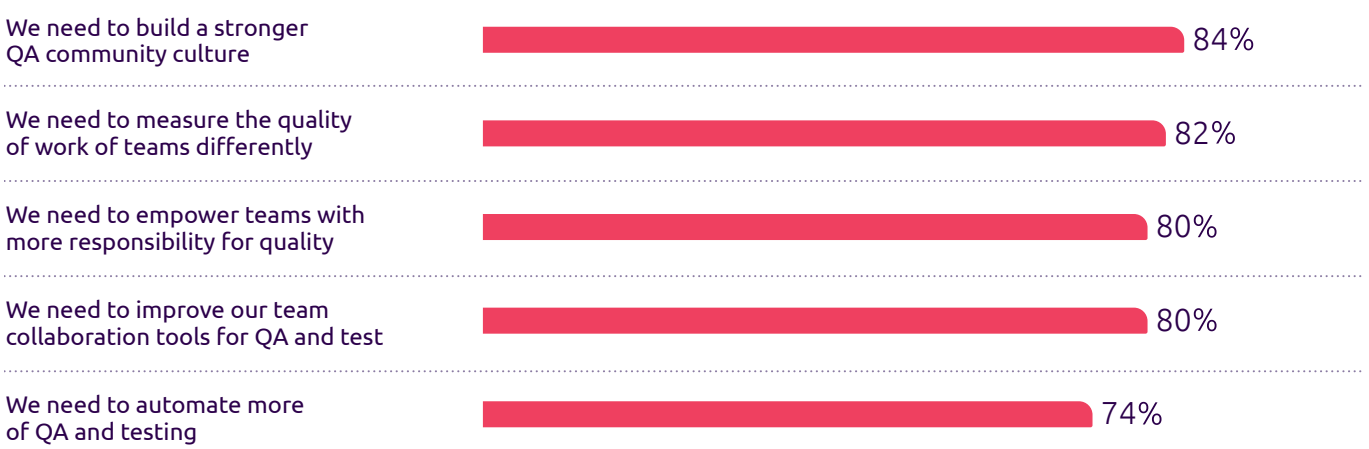
The interesting and heartening thing we witnessed is the positivity and willingness to change – to strengthen the community and collaboration and to empower our teams with greater responsibility. What emerges here is a more collective, more can-do culture. It shows a determination, as Alfred, Lord Tennyson put it, to strive, to seek, to find – and not to yield.

People can turn challenges into opportunities

"People have been using lockdown as an opportunity to round out their skills. They're seeking additional certification in complementary disciplines, so they will be ready to accept any challenge. Full-stack testing isn't just a concept – it's a reality now."

Suresh Dwadasi
Delivery head, multinational bank

Fig 18 QA in the post-pandemic world



call to action

Looking beyond the pandemic

Be better prepared for business continuity.

Frequent testing for business continuity and disaster planning needs to be conducted. We can no longer take anything for granted, be it working from a secure workplace, having a co-located workforce, or the availability of all systems within the enterprise boundaries. Being ready for any eventuality is the key. Also, the application architecture has to be tested, and to be shown to be sufficiently flexible to adapt to quick change in business models.

Focus more on security.

With the inherent security vulnerability of remote operations, and rapid changes in the way of working, it is even more imperative that organizations should become paranoid about security. Ideally the focus should be on preventing such incidents, but also preparedness to respond to any security breaches quickly and effectively in order to minimize the adverse impact.

Don't look at COVID-19 as a way to cut cost, but as an opportunity to transform.

Organizations should recognize that instinctive cost-cutting in response to this pandemic carries an inherent risk. They should instead look at re-purposing their spend to drive accelerated transformation – not just for QA, but for IT as a whole. They should use this time to accelerate digital transformation and changes to the business model, making the applications flexible and more responsive to the business changes, strengthening security and business continuity practices, and promoting a new, more collaborative way of working.

Continue to use the best practices adopted during the pandemic.

Falling back on older habits is easy. We recommend that organizations don't whittle away the best practices they have been adopting to respond effectively during these tough times. For example, they should continue to strengthen the processes adopted around remote working and operations, making the business more digital, and making cost savings on avoidable physical infrastructure and travel needs.

Sector Analysis

Automotive

The automotive industry continues to blaze trails in the adoption of new QA technologies – and is reinventing itself at the same time

Axel Schoenwald
Head of Sector,
Automotive, Sogeti

It's difficult to overstate the transition that has been taking place in the automotive industry in recent years. What's especially interesting about it is that many of its leading players are beginning to think of themselves in an entirely new way. Just a few years ago, they were manufacturers – but now, they regard themselves as mobility services providers.

This isn't merely playing with words. A car is no longer purely a mechanical device. The on-board IT plays a role that is just as important, which means that all car-makers, from recent entrants such as Tesla to established companies such as Volkswagen, are as much software companies as they are anything else. As a result, and as we noted in last year's report, what was once a monolithic business model is now built around a number of different specialist participants, both inside and outside the organization.

In-car functionality and the QA implications

We see the significance of in-car systems in this year's survey data. Almost three-quarters (71%) of automotive industry respondents said that it was an essential objective for testing and quality assurance to contribute to business outcomes. Similarly, two-thirds of automotive respondents (66%) said that ensuring end-user satisfaction was essential. These objectives are influenced considerably by the extent and usability of on-board services. Drivers, like smartphone users, tend to use only some of the functionality available to them, which is why software development and test teams need constantly to enhance the offer, including making cloud-based functions available on demand.

The shift here is from the basic 'Does the car work?' to 'Does the car do what the user expects?' In the past, manufacturers could sell a vehicle and, apart from standard after-sales commitments, pretty much forget it. Now, however, they need to remain invested in it. A large part of customer satisfaction is wrapped up in continuing digital happiness.

Cost-efficiency is also a big part of the picture. In this year's data, we see almost three-quarters of the industry's survey respondents (73%) said cost optimization was an essential element of their IT strategy. Of course, this is true for everyone – but the automotive sector has particular challenges. Many manufacturers have legacy systems, on which they are holding new telematics data, and in some cases, the worlds of factory IT and of in-car IT are set apart from one another, making cohesion and hence efficiency more difficult.

In general, automotive factory IT has a more mature approach to quality than does in-car IT, simply because

it's better-established. This year's survey shows a high degree of confidence about the extent to which targets are reached when testing key applications, and we suspect that as in-car IT quality teams catch up, these figures will be higher still. In particular, we expect to see a growing proportion of people saying they have the necessary in-house testing environments. With so many specialist organizations now contributing to the design and development of what we now need to call mobility services, overall test functionality will increasingly need to be kept in-house, where everything can be brought together and assessed in the round.

Blazing the trail in new QA technologies and approaches

It's no surprise to note that this is a forward-thinking industry. More than half of its respondents (54%) said they always shift left when testing, and even more of them (62%) said they always automate testing as much as possible.

Confidence is also fairly high as far as the use of artificial intelligence (AI) and machine learning in testing is concerned. In fact, it's not just the use of AI to test that's a factor here – it's also the actual use of AI within the vehicle, which itself needs to be tested. For example, on-board systems now include picture recognition, which is used among other things to interpret road signs and identify potential hazards. We see over two-thirds of automotive industry respondents (69%) telling us that a new strategy is needed to test AI. We also observe that a significantly higher-than-average proportion of automotive industry respondents (58%) reported that they use smart tools that predict user behaviors to help them decide what to test. This makes sense: the industry needs to understand how drivers are interacting with in-car functionality so as to improve the offer.

Similarly, there are signs of significant investment in test automation. High proportions of automotive industry respondents reported that they have the right automation strategy, that test data and test environments are available at the right time, and that they have the necessary test automation skills and experience.

However, the industry isn't complacent about its skill set. Far from it. The many test automation benefits it reports, including shorter test cycle times and better defect detection, seem to be maintaining an appetite to learn more, in order to do more. Areas of especial interest to the automotive industry in our survey included skills in robotic process automation, in test data management, and in test automation architecture.

When an industry is as keen as this one to progress in customer satisfaction, in performance, in safety, and indeed, in everything, it is hungry to learn as much as possible.

COVID-19: a factor in business model disruption

Until early this year, we were seeing the emergence of new attitudes to cars in many parts of the world. In cities especially, people were starting to think of them as a service rather than as a product. In other words, instead of owning one, they were beginning to book one online, and use it only when needed.

COVID-19 has disrupted this emerging trend. Health concerns are increasing interest in ownership once more. For instance, this summer, Citroën launched the Ami in France, an electric vehicle just 2.4 meters long, and 500 of them were sold in the first two weeks.

The pandemic has also encouraged the industry to think about its future testing and quality assurance practices. Around half of automotive respondents (49%) said they would be needing more and better collaboration tools, and a higher-than-average number (37%) said they would be focusing more on the security validation of their applications. It's likely that both these results have been influenced by the extent to which external consultants, working remotely, are becoming the norm.

A significant proportion of the industry (84%) also strongly agreed that teams need to be empowered with more responsibility for quality. Implicit in this, we believe, is an acknowledgement of the gap to which we referred earlier – that is, the gap between the factory systems management and in-car developments. As automotive organizations move further into agile practices, we can expect to see the integration of these two testing environments, and the emergence of a shared and growing commitment to quality. It will encompass everything from in-car microservices to Industry 4.0 factory floor developments, and everyone – manufacturers, suppliers and customers – will feel the benefit.

Since 1913, when Henry Ford introduced the moving assembly line, the automotive industry has always been a trailblazer. We see no signs of change at any time soon.

Consumer products, retail, and distribution

The COVID-19 pandemic has turned up the dial on quality assurance and testing trends in the CPRD sector

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In last year's report, we pointed to the particular development and testing challenges facing the consumer products, retail, and distribution (CPRD) sector. People were spending more online, which meant businesses had to meet demands in volume while still enhancing the customer experience to address specific individual needs. More function-rich applications and more transactions meant, in turn, more pressure on quality assurance (QA) teams.

If anything, the advent of COVID-19 this year has turned up the dial on all these challenges. It's not just that online shopping has scaled even further and faster; it's also that new factors have come into play.

New mechanisms and models

The consumer packaged goods (CPG) market is a case in point. Before the pandemic, companies in this subsector often had little idea of who their ultimate customers were. This is because the end-user relationship was owned not by them, but by the retailer. But now, with retail outlets in lockdown over many months, these manufacturers have realized they need to get closer to their customers. There has been a major reassessment of delivery mechanisms, not just as a way of coping during the crisis, but also for the post-COVID future.

It's an assessment that doesn't provide any easy answers. Do CPG companies continue to work with retailers, remaining distanced from their user base? Or do they invest in their own direct online channels, thereby competing with their own supply chain? Either way, and especially in the latter case, they will need to keep retailers' data separate from one another and from their own. It seems to us that, even now, they are not fully aware of how many hills they have yet to climb, nor of how steep some of those hills will be.

Implicit in all this are highly integrated cloud-based business models that are sufficiently flexible and scalable to satisfy rapidly growing and changing needs. They need to be optimized to perform during periods of high demand – and they of course need to be secure. All this is an area in which mainstream online retailers are a little further ahead, and into which the rest of the sector is moving.

Boundaries are beginning to blur. Retailers and manufacturers are starting to interact with consumers on common platforms, thereby creating new ecosystems in which the end-to-end consumer experience will be even more important. When more consumer data is being collected and stored, there will be a greater need for penetration testing, data security testing, and regulatory alignment testing.

Quality assurance (QA) is a corollary to these general trends. While we have seen no major QA developments this year, we do anticipate great levels of test automation, as well as an increasing need for customer experience functionality, which of course also has QA implications.

Also, the as-yet unseen global impact of COVID-19 will become apparent in the next year. Consumer sensitivity towards sustainability, ethical sourcing and awareness of natural resources will increase. Manufacturers and CPG companies will have another increased demand in front of them, which will be traceability. Testing models will have to tie into new technology drivers such as blockchain, which is then filtered for consumer transparency.

Customer experience – and sales team experience

Indeed, and as we might expect, ensuring end-user satisfaction and a good customer experience (CX) was rated as an essential objective of testing and QA in this year's survey by 44% of CPRD respondents – a significantly higher figure than for survey respondents as a whole, and a more popular "essential" response for the CPRD cohort than any other option, including contributing to business growth and protecting the corporate image, both at 36%.

In fact, since the pandemic took hold, we have noted the frustration of retail teams in their keenness to ensure high CX levels. In fashion and in footwear, in particular, it has been hard for sellers to know how to adapt to a changing market – a market in which customers have themselves been uncertain. We suspect that if the option in this question were rephrased to ensure a good experience not just for customers, but for retail sales teams, the response would have been much, much higher.

Strategic imperatives

We would also have expected customer experience to be the most important aspect of IT strategy overall, but surprisingly, the option rated as essential most often in this case was enhancing security, at 42%, with enhancing CX at 38%. This was significantly lower than the global average CX response of 43%. Even more bizarrely, 29% of consumer goods respondents rated faster time to market as essential, against an overall average response of just 23%. There is a puzzling dissonance here between lower-than-average CX ratings and higher-than-average time-to-market ratings, because these two factors are of course interconnected.

Also curious was the fact that just 23% of CPRD respondents rated cost optimization as an essential factor in IT strategy, against 30% for the survey as a whole. This outcome could reflect the mixed picture in the sector. In the fashion sector, costs are down because the shops are closed – but revenue is down too, of course. In the white goods market, the need for cost optimization is greater – and in food retail, cost issues have intensified because, while revenues have shot up, basket sizes and hence profitability have gone down.

Evolving attitudes

We've seen that cost optimization is significantly higher than the norm for the CPRD sector, and in a market of heightened volume, speed, and competition, we can therefore also expect to see efficiency measures much in evidence. That is indeed the case. For instance, a higher-than-average 56% of CPRD respondents rated shift-left testing as an essential step in this direction. Other highly rated efficiency measures include the implementation of smart autonomous test solutions, and the enhanced provisioning of test environments and test data generation.

All of these ratings need to be seen in the context of working in an agile development environment. This year's survey data seems to indicate that most companies in this sector have not yet fully embraced this approach. For example, a high proportion (56%) of respondents said they have difficulty in aligning the tools they should use for automated testing. Although cost optimization is important in this sector, there is some way to go before many companies fully understand the extent to which, in an agile context, testing can form an integral part of efforts to improve returns on investment in software development.

Similarly, our survey this year shows high levels of confidence among consumer goods respondents about the use of artificial intelligence in testing. We see this as aspirational rather than actual: there is, once more, a lack of understanding about the need to move from a legacy mindset, to resolve their technology debt, and to bring more modern competencies into the mix.

Looking ahead

Finally, looking at how testing and quality assurance might change in this sector in a post-COVID world, we see much determination in the responses to make improvements in areas such as building a stronger community culture, and empowering teams with more responsibility for quality.

There is much that is implicit in these aspirations. Work still needs to be done in the adoption of tools, technologies, and development environments, and once again, it seems this needs to be better understood. Service providers could perhaps help companies in the sector to see these things more clearly.

Energy, utilities, and chemicals

In spite of challenging circumstances, there are encouraging signs of progress and determination among energy, utilities, and chemicals organizations this year

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This year, the use of the word unprecedented has been, well, unprecedented; but in the case of the energy, utilities, and chemicals sector (EUC), it has been entirely justifiable. As a result of COVID-19 and near-global lockdown, demand for oil, gas, and energy fell significantly. At the height of the global lockdown, the worldwide oil demand reduced by over 30%, and the outlook for 2020 is likely to be 5–10%.

At the same time, Saudi Arabia and Russia flooded the market with oil and gas, driving down prices, and creating further pressures on margins. So, massive drop in demand simultaneous with an over-supply in the market. In order to deal with all this, EUC organizations have been taking swift action on both operating expenses and capital expenditures.

In this new climate, it's no surprise that businesses in this sector have realized the need to accelerate their digital transformation efforts, in a bid to increase their efficiency, their competitiveness, and their ability to adapt rapidly to changing circumstances. A key part of these digital transformation efforts is, of course, quality assurance (QA).

Assessing objectives…

All of this provides a good context in which to consider the industry's opinions, as revealed in this year's World Quality Report survey data. For EUC organizations, the most important testing and QA objectives were contributions to business growth (rated as essential by 42% of EUC respondents); ensuring end-user satisfaction (37%); the detection of software defects before go-live (42%); and protecting the corporate image and branding (33%). In fact, the corporate image criterion is also implicit in the other three: organizations in this sector set great store by the degree to which their brand is trusted, which is why, in a separate question, enhancing the customer experience (business or consumer) and enhancing security are rated as essential by 38% and 35% of EUC respondents respectively. It's also worth noting that the cost optimization of IT was the only aspect of IT strategy not to drop on last year's figures: it was rated as essential by a full third (33%) of survey participants from this sector.

The implicit caution in this market is also reflected in responses to a question about methods of testing digital applications. Considerably more than our survey sample as a whole, 34% of EUC respondents said an independent validation team checks quality before go-live. We see this in the field, too. It's a figure that is probably driven by the obligations of the more regulated industries in this sector.

… and agile and DevOps

It was interesting to see the extent to which agile and DevOps methodologies have been adopted in the EUC sector. As we might expect, the use of waterfall has dropped from 30% last year to 19% this year – and while agile usage is up, from 24% to 29%, DevOps has dropped, from 29% last year to 26% this year. This is curious: it may be that the line between these two development approaches is blurring for some organizations. That said, it's clear that agile is the preferred direction of travel. Among other advantages, agile lends itself to the more flexible working environment of 2020.

In a new question for this year, we asked about the various approaches organizations use to accelerate and optimize testing in agile and DevOps environments. As we might expect, the most popular responses for EUC respondents were shift-left testing, and maximizing the use of test automation – although the figure of 52% of respondents for this latter category seems unlikely. We feel test automation is not being used to its full potential by as many organizations as that, so it will be interesting to see if that figure changes next year, as people take stock of their position.

What was not at all surprising was the proportion of EUC respondents who said they always proactively monitor and review production logs for incidents, and performance trends, in order to identify application issues and potential defects even before end-users might notice them. At 35%, the EUC response was substantially higher than the 28% average for our survey as a whole. This is likely to be because of the critical nature of this market, where safety is such a high priority.

As we would expect, the desire for more skills in QA and test is high. For instance, 37% of EUC survey participants – considerably more than the survey average of 29% – said they need greater knowledge of test automation skills. We do see higher progress in the pursuit of QA skills than in many other sectors, but to some degree, we feel aspirations are running ahead of reality.

The move to smartness

Energy, utilities, and chemicals businesses are interested in the QA potential of artificial intelligence (AI) and machine learning (ML), and we see that interest reflected in this year's survey. Smart QA options highlighted by EUC respondents as highly relevant included automated root cause analysis, at 66% – much higher than the 58% survey average. In industries as regulated as these, that makes absolute sense. So, too, does defect prediction, which at 40% of EUC respondents is much higher than the figure of 29% for the survey as a whole. Businesses in this sector have high duties of care with respect to safety and the environment.

This might explain why the need for data science skills, mentioned by 37% of EUC respondents last year, has dropped to 27% this year: the industry seems to have recognized that need, and has been addressing it.

In fact, generally speaking, organizations in this sector seem fairly upbeat about their progress in AI and ML as far as quality assurance is concerned. For example, as many as 83% of them feel their current test strategy will work for AI as well, and 88% enthusiastically agree that AI is the strongest part of their testing activities. We feel these are things they would not have been able to say even as recently as two years ago.

Coping with COVID-19

The global pandemic has obliged all businesses to take stock, and many respondents to this year's survey said their testing and QA focus would be changing as a result. The most marked response from the EUC cohort related to an increased focus on the security validation of applications: 45% of EUC respondents placed high emphasis on this, against just 31% as a global average. This is to be expected: EUC cyber incidents have risen considerably during this crisis.

The impact on QA and testing budgets is not anticipated to be as high as in other industries: an average budget decrease of 9% is suggested by our EUC respondents, against a survey average decrease of 13%. This is likely to be because of the nature of this market, and in particular because of its regulatory obligations, and also because of the importance of maintaining brand profile in a sector that is so under the spotlight.

Finally, what's heartening about the reflections of energy, utilities, and chemicals businesses on the ramifications of COVID-19 is the extent to which they indicate new levels of optimism. Almost nine in ten EUC respondents (88%) forcefully agreed they need to build a stronger QA community culture, and almost as many (82%) said they need to empower teams with more responsibility for quality.

We see this as part of a bigger picture. Industry-wide, we sense a determination to turn the pandemic into an opportunity, and to accelerate into scale in the transformation of the digital landscape.

Financial services

Despite upheavals, financial services organizations are continuing to evolve QA dynamically – and to beat a path for others to follow

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The financial services sector is obliged to be fast-moving, which is why it tends to be at the forefront in the adoption of new technologies and approaches. In last year's World Quality Report, we noted the sector's capacity for innovation in quality assurance (QA), in particular. We also mentioned that testing and QA were in many cases being absorbed into the mainstream of the software development lifecycle.

In these main respects, there are few signs of change in this year's report for the financial sector, which at 19% of our total survey cohort remains the single largest sector we have consulted. Indeed, when asked about testing and QA objectives, the highest-rated responses from the sector included the contribution to business growth; ensuring end-user satisfaction; detecting software defects before go-live; and achieving quality at speed. This last response is of particular importance to financial services. Agile development environments can facilitate speed improvements, which is why moves in this direction are often an objective here.

These objectives for testing and QA are also important for the IT strategy as a whole – but in this case, factors such as the customer experience, business responsiveness, and faster time to market are joined by the need to enhance security, which, as one might expect, is given the highest mean rating of all.

In general terms, we see a fair degree of optimism as far as achieving various targets for application development is concerned. Two-thirds (66%) of financial services sector respondents said their testing pretty much always covers everything that is needed. Almost as many (63%) said their applications development across distributed teams is almost always well orchestrated and integrated, while 59% said their end-to-end automation, from build to deployment, is virtually always in place. These responses are a sign of the high levels of maturity in this market, and they also indirectly indicate the extent to which agile and DevOps are being adopted.

The sector is equally upbeat about the ability of its teams to meet various testing targets. In almost every category – such as meeting quality goals, having the right QA and test expertise, and having the right testing strategy, process, or methodology – it returned highly positive results that were higher than for survey respondents as a whole. In only one instance was it lower than the global average, and that, perhaps unsurprisingly, was the availability of sufficient time for testing.

It was interesting to see the extent to which financial services QA teams use different methods of

testing digital applications. Only a quarter (25%) of respondents in this sector said they use independent validation teams to perform quality checks before go-live. By contrast, for the energy, utilities, and chemicals (EUC) sector respondents, this figure was 34%. We feel this is an indicator of the extent to which QA is more integrated, more optimized, and more mature than is the case in some other sectors. As we noted last year, so here also: QA is becoming the responsibility of the entire software development lifecycle team.

Development environments

Agile and DevOps have already featured in this assessment, so it's worth noting year-on-year developments in this regard. For agile, 27% of financial services respondents reported usage, up from 25% last year. For DevOps, 29% reported usage, up from 27% last year. And for waterfall, 20% reported usage, down considerably from 32% last year. It's no surprise to see those increases for agile and DevOps, but as we can see here, the extent of the drop of waterfall doesn't create a balance. It could be a matter of perception: in other words, the better outcomes from agile and DevOps are skewing the picture. It could also be related to the extent to which respondents are validating across the entire lifecycle. Whatever the case, we note that the same imbalance can also be seen in the survey-wide figures, and not just for this sector.

What approaches are QA teams using to accelerate and optimize testing in agile and DevOps developments? Half (50%) of financial services respondents said they are always or almost always maximizing test automation. Interestingly, as many as 55% said they are virtually always adopting shift-left techniques; almost half (47%) said they are testing less during development, and focusing more on quality monitoring and production testing; and a third (33%) said they almost always implement automated quality dashboards to enable continuous quality monitoring.

These responses collectively suggest a more integrated and continuous approach is developing, and that past distinctions between QA and development are indeed beginning to blur. What's more, our survey suggests there is a desire to maintain the momentum: when identifying skills gaps, highlights for financial services sector respondents included test automation skills (34% of respondents) and development skills (31%). These corroborate the shift we are seeing to the left, as well as towards a continuous integration/continuous delivery (CI/CD) approach.

Looking ahead on AI – and to a post-COVID world

A similar degree of confidence is evident with respect to the use of artificial intelligence (AI) and machine learning (ML) in quality assurance. More than four in five (81%) financial services sector respondents emphatically agree that their current test strategies will work for AI as well, while the same proportion (81%) felt that only small changes to their current test strategy would be needed.

In general, our view is that the application of AL and ML to quality assurance in this market is suitably crafted, and is working well – but that its full potential has not yet been reached.

This is corroborated by our assessment of responses to a question about plans for AI in testing. A very high proportion of our financial services sector respondents (93%) wholeheartedly agreed that AI is currently the strongest area of growth in their testing activities. This seems to be an acknowledgement that they are not yet where they feel they need to be, and that they are keen to move ahead. Indeed, in our experience, AI is only being implemented in pockets, rather than across the full spectrum of QA activities.

We also asked people to look ahead to a post-COVID world. How did the financial services sector think QA and testing might change? Significantly higher than average numbers of them strongly agreed, first, that they needed to measure the quality of work of teams differently (88%); and second, that they needed to automate more (79%). In a world in which working more from home is likely to be normalized, the metrics by which testing is assessed may need to be recalibrated.

Taking stock

Overall, this year we feel that, despite the upheavals that 2020 has brought, quality engineering in the financial services sector is continuing to evolve. It is becoming more mature, and more integrated, and while to some extent organizations are still feeling their way on AI, they are moving towards a continuous testing environment, and they are adopting agile and DevOps to help facilitate this.

That said, though, we don't anticipate the move to agile and DevOps to be either rapid or wholesale. We rather expect a hybrid development environment, also encompassing waterfall, to remain in place for some time to come.

Healthcare and life sciences

Healthcare and life sciences organizations remain committed to automation and AI in their QA efforts

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In the healthcare and life sciences section of last year's World Quality Report, we noted that the sector was subject to significant pressures as far as cost containment and time to market were concerned. In quality assurance (QA) in particular, we observed that the general pressure on costs carried through to budget constraints for testing, and indeed for all of IT. Nonetheless, we said, there was a clear appetite in this industry to invest in intelligent automation, and also in artificial intelligence (AI) and machine learning (ML).

In the year that has passed since then, we've grown accustomed to seeing the major upheavals that have been wrought by COVID-19, and so in the healthcare sector, it wouldn't be surprising to see the same thing happening. In fact, though, pretty much everything we see this year is the same – pressures on cost, pressures on delivery, and the pursuit of automation and AI in order to relieve those pressures.

The difference, of course, is in intensity: it seems everything is happening harder, and faster. Healthcare and life sciences organizations are looking for quality at speed and on a budget, and they are turning to automation and AI to help them get there.

Objectives, strategies, and successes

In fact, quality at speed are exactly the words used in one of our key survey questions this year. We asked how important various objectives were when it comes to testing and QA, and almost two-thirds of healthcare and life sciences respondents (64%) said that this was key. It was essential, they said, that software should be released faster, but without compromising quality. The three most popular responses to this question were also to be expected: detecting software defects before go-live (79%); contributing to business growth (76%); and ensuring end-user satisfaction and a good customer experience (also 76%).

We also asked people to rate the importance of different elements of their IT strategy. The need to enhance security was marked high, at 80%, but so, too, was the cost optimization of IT, at 69%. Given the emphasis on quality at speed that we just noted, we were a little surprised to see faster time to market rank lower on this question, at 62% – especially when time to market is directly related to higher responsiveness to business demands, which was ranked high by 71% of this sector's respondents.

It was interesting to see how well healthcare and life sciences survey participants seem to understand their success as far as achieving their application development targets was concerned. The categories for which they gave themselves

the best ratings were, as we would expect, the completeness of their testing, the sufficiency and availability of their tools and methods, and the extent to which their application development across distributed teams is orchestrated and integrated. The categories for which fewer of them gave high ratings were the achievement of end-to-end automation, the clear definition of requirements, and testing efficiency in terms of speed and cost. In all these cases, there is indeed work still to do.

Development environments and budgets

This year's survey also showed a gradual increase in this sector in the use of agile and DevOps environments, and a marked decrease in the use of waterfall. We see these same trends in the field. To accelerate and optimize QA in agile and DevOps, techniques being mentioned by healthcare and life sciences respondents include shift-left testing (used a great deal by 49%), and integrating tests as automatic quality gates in the continuous integration/continuous delivery (CI/CD) pipeline (42%). We see interest in CI/CD growing in the sector alongside that for automation, and this is reflected in responses relating to skills needs: over a third (34%) of sector survey participants said they needed to work on their skillsets in these areas.

Given the cost containment pressures we mentioned at the outset, it is a surprise to see the extent to which QA and testing has dropped as a proportion of overall IT spend this year. Last year, the figure was 25%; this year, it stands at a reported 21%, which is one of the biggest differences we have seen in any sector. One possible explanation is that test automation is delivering cost efficiencies, and indeed, we do see a slightly higher-than-average spend on software tool licenses in this sector. This theory might also be corroborated by the number of sector respondents who see the importance of increasing the level of test automation, which at over a third (34%) was also higher than average.

AI and automation

A very high proportion of respondents in healthcare and life sciences (86%) emphatically agreed that AI is currently the strongest growth area in their test activities.

However, the area in which they feel they are making the most progress is, as we have seen, test automation. Over two-thirds (68%) of them said they have the required automation tools, and the benefits they perceived included, as we would expect, better control and transparency of test activities (rated highly by 68% of respondents), reduction of test cycle time (64%), and reduction of test costs (63%).

In our survey, plans for the use of automation in the coming year include the use of model-based testing tools, and also of robotics automation, which we have ourselves seen used in the field, especially for risk-based testing.

Adjusting to COVID-19

Inevitably, the focus for testing and QA has been affected by this year's pandemic. Respondents in this sector reported that they expected to increase their emphasis on customer experience validation and usability testing (rated highly by 57%). In a world that has been working from home, it is no surprise to note that 55% said they needed more and better collaboration tools for their teams, and that they needed more remote access to test systems and test environments. In both these latter categories, responses for the sector were significantly higher than for our survey respondents as a whole.

Respondents felt the drop in QA and testing budgets that we noted earlier is likely to continue, with an average predicted decrease of 17% – one of the highest predicted sector drops we have seen this year. Once again, the benefits of automation may be a factor here. Also, faster time-to-market results may be reducing cycle times, and hence also reducing pressures on budgets.

Looking ahead

Many of the key points that have emerged in this year's survey are trends that we have seen for ourselves in the healthcare and life sciences sector as whole. Faster time to market remains a goal; so, too, is the use of automation to boost efficiency; and we also see the growing use of AI to improve and streamline processes. We don't expect these technologies to deliver fully zero-touch testing any time soon, but designating that as an objective will deliver many benefits along the way.

It's all part of the sector's interest in making continuous testing a reality – and in this respect, we anticipate that a real push in DevOps will be a key enabler. Watch this space.

High-tech

High-tech organizations continue to blaze the trail with test automation and user experience testing – and they are making QA everyone's responsibility

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In the 2019 edition of the World Quality Report, we noted high-tech was a trailblazer among sectors in its approach to quality assurance (QA) and testing, and that is still very much the case this year. It's an approach that is seeing QA being gradually subsumed into the software development lifecycle, with test engineers making way for multi-skilled Software Development Engineers in Test (SDETs), and with federated structures rather than centralized QA functions.

Test automation is continuing to increase in significance, and we also see increasing emphasis being placed on continuous testing and DevOps environments, and also on user experience testing, which is a major source of differentiation in this industry.

Business-oriented, user-oriented quality

The business-led nature of quality assurance in the high-tech sector is very much in evidence in this year's survey responses. Contribution to business growth is ranked as a highly essential objective by as many as 85% of the sector's respondents, against 74% for the survey as a whole. End-user satisfaction is similarly higher than average, at 74%. We also see a marked difference between the sector and the total cohort on the importance of supporting everybody in the team to achieve higher quality. This is an essential objective for two-thirds of sector respondents, against 60% for the survey total. It's a statistic that corroborates the principle of the SDET approach.

We were surprised to see only half of high-tech respondents (50%) saying they pretty much always achieve well-orchestrated and integrated application development across distributed teams. The cohort of respondents for this sector includes people from hardware and aerospace industries, and we suspect this may have skewed the figure. The high-tech industry in general is very much accustomed to working in distributed teams. Indeed, this holistic approach is an essential part of what is being termed summative usability testing, in which the usability of software design is tested from end to end.

This year's survey bears witness to this. It shows that user acceptance and performance testing are conducted in high-tech to a much higher degree than for survey respondents as a whole. Similarly, almost a quarter (24%) of high-tech respondents said they very frequently use crowd test services before a software release, for in-the-field design evaluation. The survey average for crowd testing was lower, at 19% – but for high-tech, this is a hot area right now.

Agile, DevOps, test automation, and AI

In most other sectors covered in this report, the year-on-year increase in use of agile and DevOps environments has been steady, but slight. That's not the case here: our high-tech respondents reported a full four-point increase in use of both environments, to a mean summary of 26% for agile, and of 28% for DevOps. At the same time, the mean average for waterfall dropped from 30% in 2019 to 20% this year. In a trend-setting market such as this, these shifts aren't surprising, although we suspect these reported figures may not acknowledge the degree to which agile projects are being conducted within a broader waterfall legacy context.

The sector is also setting the pace in the acceleration and optimization of testing in agile and DevOps developments. We found that 29% of our survey respondents as a whole said they were using tools to generate or update tests automatically – but as many as 39% of our high-tech respondents said the same. We see this a great deal in the field: the use of self-healing and self-updating tests is becoming much more prevalent.

This is why we see a significantly higher-than-average number of respondents in this sector assigning a high level of importance to the removal of redundant tests (39%, over a survey average of 34%). The popularity of test automation is also made clear in the importance attached to the implementation of intelligent autonomous test solutions (64%, over a survey average of 54%), and increasing the level of test automation (40%, over a survey-wide figure of 31%).

A further area in which high-tech is blazing a trail is in the use of artificial intelligence – not just in testing, but in general application, too. Think, for instance, of all those voice-activated interpretative apps that can set your alarm for next morning, or add milk to your shopping list, or tell you the capital of Mongolia (Ulaanbaatar, by the way). It's why in this year's survey, we see more than three-quarters (77%) of respondents in this sector strongly agreeing that they will take advantage of AI technologies in testing for the testing of AI. It's also why 91% of them said that, whether they are testing AI or testing with it, artificial intelligence is the strongest growth area in their activities right now.

Time savings: the main test automation benefit

Time pressures are a perennial problem in IT, so it is at first surprising to see that as many as three-quarters (75%) of respondents in the high-tech sector said they have enough time to build and maintain their automated tests, against a survey average of just 63%. We feel this high figure may be because of the extent to which QA teams in this sector are adopting DevOps. Working in this environment means these teams are likely to start writing their automated tests very early in the cycle. This saves them time later, not least because it makes those automated tests easier to maintain.

Indeed, the benefit of test automation that this industry sector perceived to be highest is the reduction of test cycle times, mentioned by 76% of our high-tech respondents.

The benefit attracting the lowest response for high-tech was the better detection of defects, at 53%. This is indeed a disadvantage of test automation: what its users gain in speed of execution, they to some extent lose in effectiveness.

A further downside to the growth of test automation is evidenced in a question relating to skills. A full third (33%) of high-tech respondents said that their organizations were lacking in test case design skills. This is a core skill of legacy manual testing, and in an environment that is shifting to automation, it tends to diminish.

The COVID-19 effect: more of the same

It's interesting to note that in the case of the high-tech sector, this year's pandemic has intensified current trends, rather than changed them. Areas of focus that are predictably more important for this sector post-COVID than for respondents as a whole include security validation, and customer experience validation and usability testing. Lower-than-average areas of focus included the need for better team collaboration tools, and a greater emphasis on performance validation – but this may be because in these two areas, the high-tech sector feels pretty much on top of things as they stand.

In a post-pandemic world, the yardsticks by which the industry currently measures itself will still be very much in use. They reflect the trends we have seen throughout this analysis, and include an emphasis on test automation, and a stronger, more collaborative QA community culture, in which responsibility for quality is not assigned to a designated team, but is shared by everyone.

Government and public sector

Serving the public in challenging times – with a new determination to change business-as-usual in quality assurance

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In the introduction to last year's public sector analysis in this report, we noted that while the mechanisms of government and of public sector organizations may vary by country or by region, what all such bodies have in common is a duty towards the citizens they serve.

This has never been a more important truth to recognize. Like every other market and industry in this report, the public sector is working towards a smarter, more efficient, and more cohesive approach to quality assurance (QA) – but in 2020, it's doing so under the weight of public expectations surrounding the global pandemic.

We'll come to COVID-19. First, though, we'll consider the general picture, as seen by our public sector respondents, who represent 15% of our total survey sample.

Business growth – and customer experience

As we also did last year, we asked participants to rate the importance of various QA objectives. In line with the survey as a whole, public sector respondents rated the contribution to business growth (43%) and the importance of the customer experience (39%) as the two most important factors. Even so, and despite the fact that the business growth response was up from 38% last year, the figures were lower than we expected.

The most marked difference between public sector responses and the global total was for the importance of protecting corporate image. The general figure was 36%, but for the public sector, it was 44%. This, for us, is not surprising at all: the global pandemic has intensified the spotlight on public services. Of less importance to our public sector respondents was faster time to market, at 21%. It's true that overall quality is more important in this sector than speed, but even so, we thought this figure was somewhat low.

Generally speaking, public sector survey participants were sanguine about their ability to meet their application development targets. As many as 62% of them said their testing covers all that is needed, and 60% said end-to-end automation, from build to deployment, is in place. In our experience, automation in the sector is patchy, rather than end-to-end, and there is some way to go, too, in clearly defining requirements (47%).

Respondents were similarly optimistic about the extent to which application development is orchestrated (57%): we feel more effort is needed here.

Development environments and skills

Responses to preferred development environments were mixed. A quarter (25%) of public sector survey participants said they worked in agile, while 30% used

DevOps, and 20% used waterfall. Last year, a third (33%) of people in this category said they used waterfall. We feel these numbers reflect the hybrid nature of the QA environment in this sector: many individual delivery groups are working in agile and DevOps, but – possibly without their knowledge – they are doing so within a broader, waterfall-based context. Who is answering the question here may be a factor in the difference in the figures – and another factor may be the lack of professional test expertise in agile teams, cited by 43% of public sector respondents.

Indeed, deficient skills in general identified by this sector all average out at around 25% of respondents, and include test case design skills, collaboration skills, and data analytics and AI skills. Knowledge of business processes also featured, with 24% of public sector respondents, which is a little disconcerting: business knowledge is necessary in order to know what to test.

Overall, these skills requirements tell us that what's needed is a plan – a means by which these gaps can be identified and filled in an orchestrated way. There is clearly work to be done here.

Testing efficiency and automation

In a new question for 2020, we asked people to rate various approaches to increasing testing efficiency. Well over half of public sector respondents (58%) rated shift-left testing as essential or as highly important. This is a trend we see in the field, and incidentally, we also see some emphasis on shift-right testing, where lessons learned in production are played back into design revisions and updates. Other high-scoring responses to this question included test environment provisioning and test data generation and provisioning, which are indeed major factors for the public sector organizations we encounter.

For test automation, the public sector picture is fairly positive, and is broadly in line with our expectations. Almost two-thirds (64%) said test data and test environments are available at the right time, and 62% said they have the right automation tools. As many as 70% of public sector respondents said they have the right automation strategy – but of course, it's the implementation rather than the strategy that is a challenge, particularly when there are pressures of time, a constant imperative to deliver policy change, and a relentless requirement to modernize the sector.

The three most frequently cited automation techniques that public sector respondents are planning to use this year were model-based testing tools (47% were extremely or highly likely), test environment visualization (46%), and robotics automation for test activities (47%). We regard all of these as key, and expect to see further developments in these areas.

The public sector and COVID-19

In our experience, public sector organizations have been responding well to the new operating circumstances created by the global pandemic. The transition to working from home was largely smooth, and there have been few blips in service. Team members have embraced the need to communicate, and to work as a group.

We've also noted how the ground rules for design, development and QA have shifted. Solutions are built to be simple and streamlined. It's good, outcome-oriented work, rather than innovation for its own sake, and a key part of this is an increased focus on understanding the entire customer journey, building and testing integration end-to-end so everything will work first time.

Public sector bodies have been quick to recognize these benefits, and are looking at how the new working practices they've put in place in difficult circumstances can become part of business-as-usual once pandemic measures are eased.

The survey data endorses our analysis. When asked to look beyond COVID-19, just over half (51%) of public sector respondents said they were highly likely to be focusing more on customer experience validation and usability testing. This was a higher response than for survey participants as a whole, and indeed, other forward-looking statements were also higher for the public sector, including improving team productivity monitoring; acquiring more and better collaboration tools; and improving the orchestration of QA activities across teams. These trends are to be expected: more than in many other kinds of organization, public sector bodies need to be seen to be delivering well, and in particular, in terms of the customer experience.

Finally, we asked our respondents to take stock in a broader way. Almost nine in ten (87%) public sector participants strongly agreed that they needed to build a stronger QA community culture. Over three-quarters (78%) of them also strongly agreed that they need to measure the quality of their teams' work differently, and also to empower teams with more responsibility for quality.

It's all true. What the pandemic has brought about is not a blip. A change is needed to business-as-usual, and we can expect to see public sector organizations continue to put their commitment in this respect at the front and center of their QA efforts.

Telecoms, media, and entertainment

TME organizations need to develop a more cohesive strategy to quality assurance – and they are determined to do so

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In markets such as telecoms, media and entertainment (TME), it's highly likely that most of the trends we observed last year will be true again not just now, but for the foreseeable future. For instance, in 2019, we noted that these were sectors that were highly customer-driven, and that were therefore complex. We also saw that they were under high time-to-market pressures. We observed growth in the sector's installed base of internet of things (IoT) devices, which had quality assurance (QA) implications, and we noted a need for test automation to help address this workload.

None of these challenges are likely to diminish any time soon. The one challenge of 2019 that is less of an issue at present is the effect that the advent of 5G might have on the QA picture. It's a development that hasn't really scaled yet, and so we have yet to see any large-scale consequences for quality.

On the flip side, there is one challenge being faced by QA teams in the TME sector this year that wasn't an issue at all in 2019. That, of course, is the effect of COVID-19. We'll return to that later.

Objectives and successes

The perennial challenges we've noted perhaps explain why one of the most important objectives in our survey was judged by our TME respondents to be to make QA and testing a smarter, automated process (rated highly by 70% of the sector's participants, against a survey-wide average of 62%). Telecoms systems are complex, and are highly coupled from the back to the front end: it's almost impossible to isolate a system in this environment. What's more, these systems are disparate: many of them are new, but some of them are legacy. It's little wonder test automation is given such a high priority.

How well do QA teams in the TME sector feel they are doing in the achievement of their application development objectives? They seem to feel pretty successful: against most options, they posted higher-than-average ratings. These options included the completeness of their testing; the sufficiency and availability of their tools and methods; the achievement of end-to-end automation; and the clear definition of requirements. Perceived success in testing key applications is also high.

In our view, the scores given are optimistic. While it's true that many organizations are achieving "wins" in individual parts of the testing and QA process, that doesn't necessarily mean that the general successes being logged here can be inferred. Nor does it necessarily mean that work is being conducted in accordance with an overall plan. This may, in turn, explain why TME survey participants posted lower-than-average responses when asked about how efficient their testing was in terms of speed and cost.

Agile and DevOps: more strategic thinking needed

We see a gradual rise in TME organizations in their reported use of agile and DevOps environments, and a simultaneous decline in their use of waterfall. This is broadly in line with the trends we see across our survey as a whole – which, considering the complexity we have noted in these industries, is quite a heartening development.

However, it's not without its challenges. In agile development, more than half (53%) of TME respondents said they had difficulties with aligning the tools for automated tests, and almost as many (48%) said they had a lack of professional test expertise in their agile teams. These indicate a tactical approach, swapping tools in and out to see what works, rather than working strategically, within a single, consolidated ecosystem.

Our survey also shows that many TME respondents are trying various ways to accelerate and improve testing in agile and DevOps environments. Faster testing can, of course, be achieved in one of two ways: either simply by doing things more rapidly, or by reducing non-productive time as much as possible. This can be hard to do, and many of the routes being adopted – such as integrating tests as automatic gates in the CI/CD pipeline, or finding and removing redundant test cases – can be hard to measure.

Moving forward in automation

A higher number of TME respondents than our survey average reported they are getting a return on their investment in test automation. We feel that, in this complex environment, it is perhaps a little easier for some TME organizations to find some low-hanging fruit. However, as we have already noted, successes in individual areas don't necessarily denote a comprehensive plan.

Other automation benefits mentioned by TME survey participants include better control and transparency of test activities, and a reduction in test cycle times. Curiously, however, fewer of them noted reductions in test costs, and better test coverage. It's hard to gauge how much of this is real, and how much may be wishful thinking.

It's possible the picture may change over the year to come: when asked about their automation plans, more than half (57%) of our respondents from these industries said they would be using model-based testing tools. This is an approach we have already started to see in practice.

COVID-19: re-evaluating the QA approach

We've seen some of the effects of COVID-19 on the TME sector for ourselves in the field. Externally, for instance, customer organizations have been obliged to reconfigure their call centers to enable staff to work from home, which has had significant implications for telecommunications QA teams. Internally, we've seen many of last year's capex projects shelved in order to free up budget to fix operational issues.

This increased activity may explain why the effect of the pandemic on QA budgets is anticipated to be less severe than in some other sectors. Two-thirds (67%) of our respondents in these industries said they expected the budgetary impact to be between zero and a decrease of 10%.

One of the most interesting areas for us was the extent to which TME organizations now seem to be reevaluating their approach and their goals in the context of COVID-19. A higher-than-average proportion of them strongly agree that they need to empower teams with more responsibility for quality (82%); that they need to build a stronger QA community culture (87%); and that they need to measure the quality of work of their teams differently (also 87%).

Until now, we've been growing accustomed to observing what might be termed a shop-floor mentality in QA in the TME sector, where teams achieve outcomes via case-by-case workarounds, and where a sense of overall success is unreliably derived from these individual instances. But what we're seeing here in these responses seems to be a shift in attitude. TME organizations may have started to focus more on the means by which they get to their destinations, rather than on the mere fact of their arrival. In short, we may be seeing an evolution from a set of rough-and-ready QA tactics to a more cohesive QA strategy.

Summary

Last year, we concluded by saying that there were challenging but exciting times ahead for TME organizations. At the time, of course, no one knew quite how challenging the last year would be.

The good news is that, even though there are signs that the industries have been over-optimistic in their assessments of themselves, there are also indications that a greater capacity for clear-sightedness is emerging.

Telecoms, media and entertainment businesses are very can-do. It's in their DNA. If they can couple this with a more strategic and holistic approach to quality assurance, the future could look very promising.

About the study

World Quality Report 2020-21

The World Quality Report 2020-21 is based on research findings from 1,750 interviews carried out during June and July 2020 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 40 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 five 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/CTOs and VP/Directors of Research & Development, we are able to bring in their views and insights in the space of product, engineering and digital manufacturing services for the automotive, healthcare and life sciences, and high-tech sectors.

The research sample consists mainly of senior-level IT executives.

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.

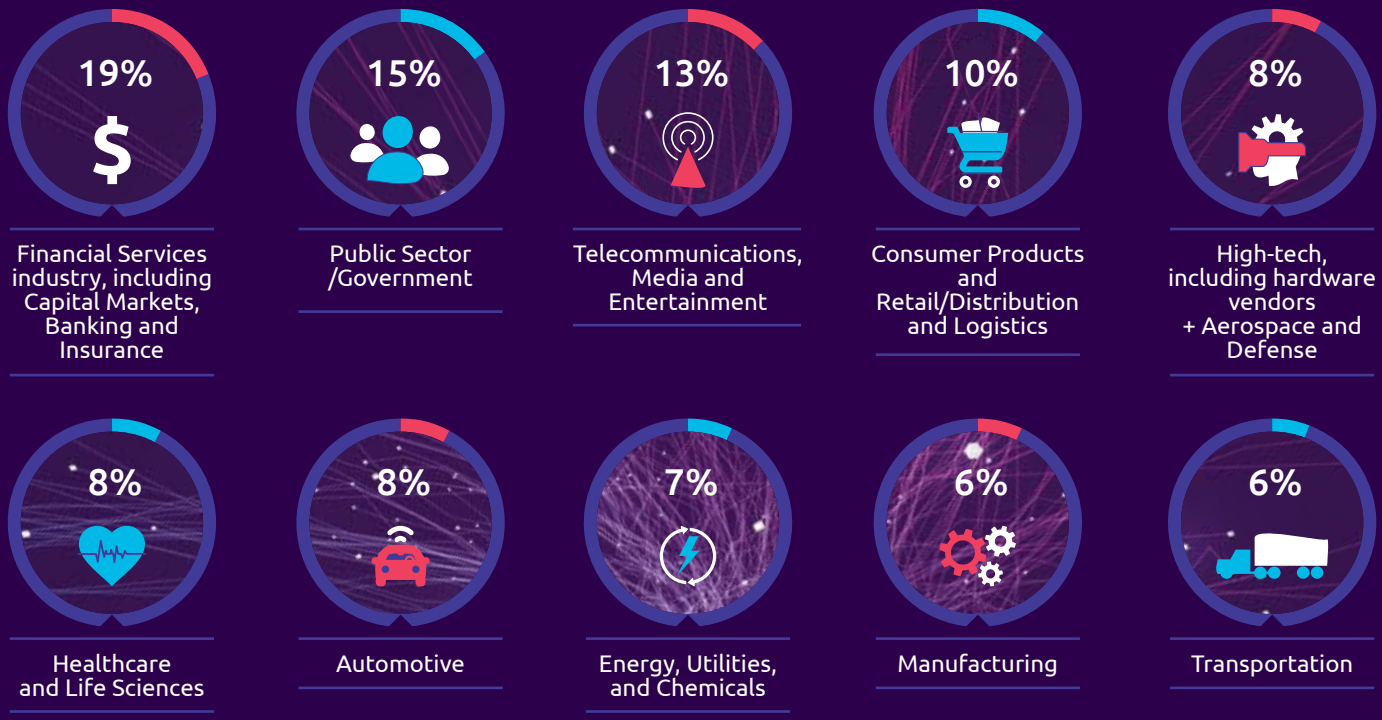
The required sample size varies depending on the population it represents – usually expressed as a ratio or incidence rate. In a business-to-business (B2B) market research study, the average recommended sample size is 100 companies. This is lower than the average sample size used for business-to-consumer (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 2020-21 is based on a sample of 1,750 interviews from enterprises with more than 1,000 employees (25%), organizations with more than 5000 employees (34%) and companies with more than 10000 employees (41%). 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 1,750 sample size.

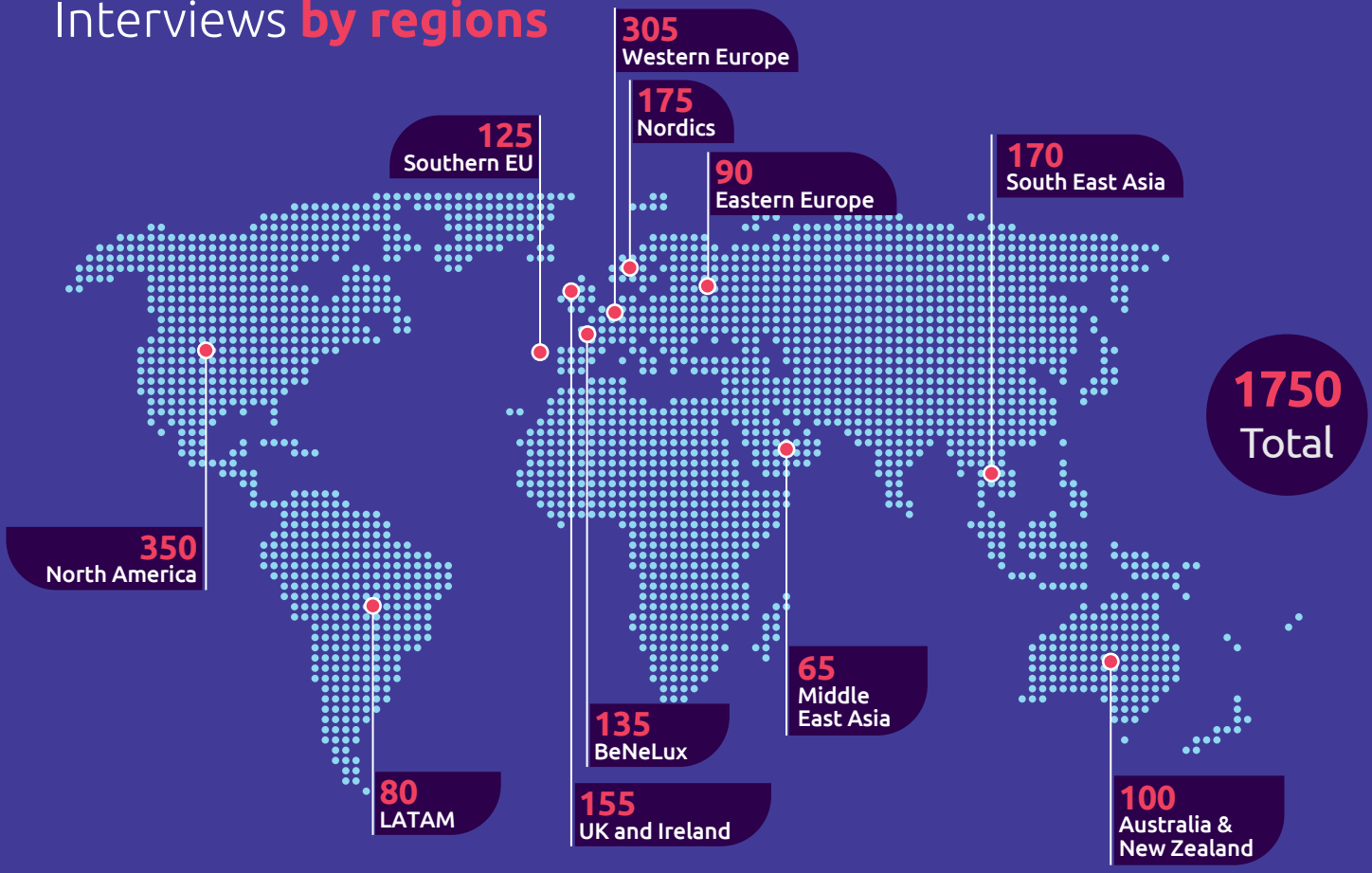
The survey questionnaire was devised by Digital Assurance and Quality Engineering experts in Capgemini, Sogeti and Micro Focus (sponsors of the research study), in consultation with Coleman Parkes Research. The 40-question survey covered a range of software quality engineering and digital assurance subjects, enriched by qualitative data obtained from the additional in-depth interviews.

Interviews **by sectors**



Interviews **by job title**

Interviews **by regions**



Interviews **by number of employees**

About the Sponsors

World Quality Report 2020-21

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Thank you

Capgemini, Sogeti and Micro Focus would like to thank

The 1,750 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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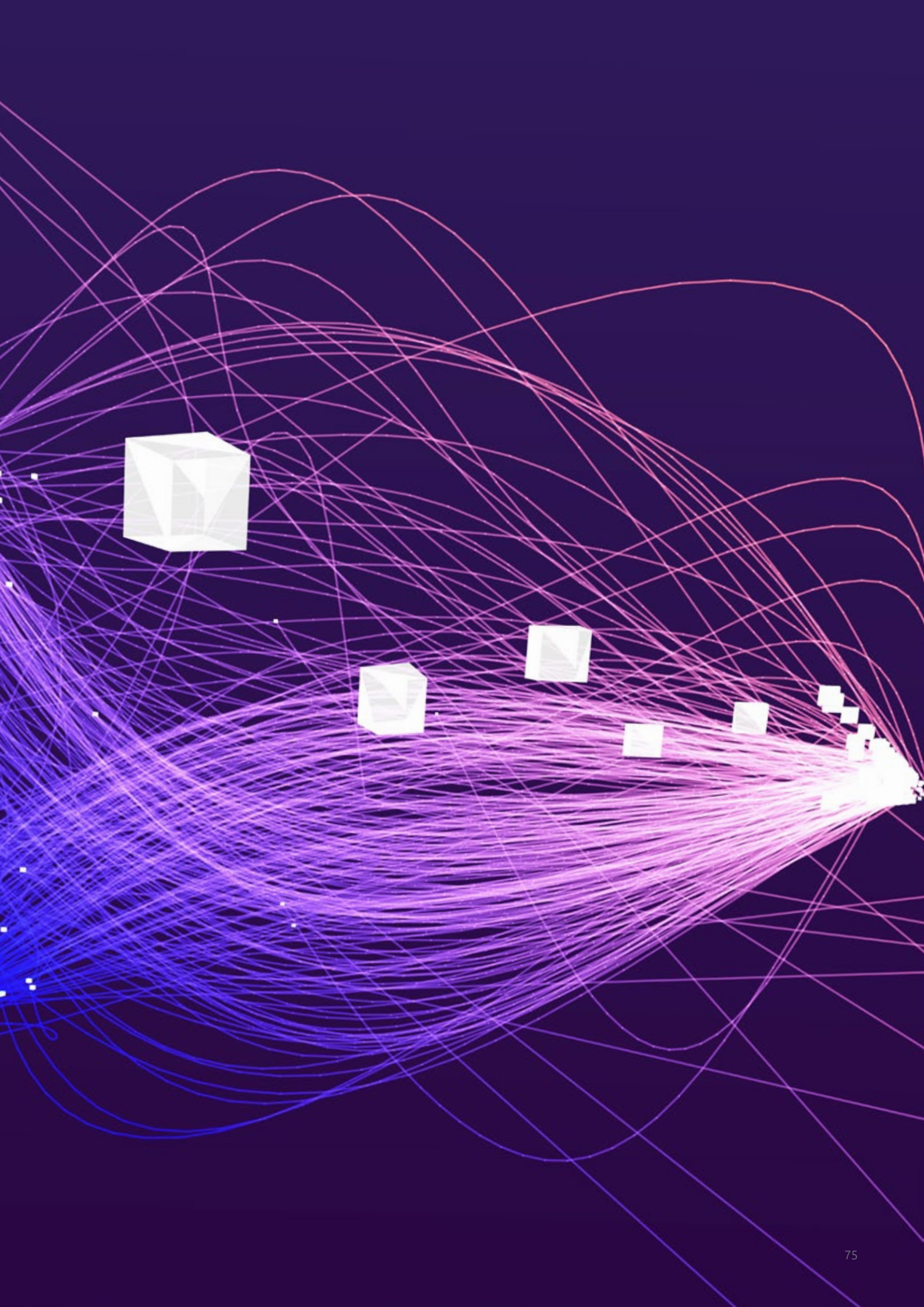

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