WORLD QUALITY REPORT

2021-22 | THIRTEENTH EDITION

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WORLD QUALITY REPORT

2021-22

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INTRODUCTION

MARK BUENEN

Global Leader
Digital Assurance and Quality
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> Welcome to the 13th edition of the World Quality Report. It's a great honor for us here at Capgemini and Sogeti to publish the latest annual assessment of quality engineering.

In fact, the World Quality Report is not just an assessment. In addition to the analysis of current trends, and the examination of developments by sector and by region, we also make recommendations. It's our aim to show what's happening in the field, what the best practices are, and how organizations might take advantage of them.

CHANGING TIMES

Over the last years we have seen several major trends that are driving changes in quality assurance (QA) operations. Each year, we adapt our survey to these changes. We have seen that IT activities overcame the COVID-19 crisis with relative ease, and the transition to working in distributed virtual teams happened almost effortlessly. So we decided to address the impact of the pandemic in a more generic way this year, and not in a dedicated chapter. Also, the transformation to agile/DevOps is continuing. With that, QA and testing have become an inclusive activity within development, and the questions around budget-allocation for test have become more and more meaningless. So, for the first time, you will not find a dedicated chapter on budget and cost-containment for test.

What's new to the report? We've introduced a section on intelligent industry. Organizations are increasingly looking at how to digitize the key industrial parts of their business. They are using embedded software, data, 5G, edge computing, and artificial intelligence (AI), and although this is still an evolving area, quality engineering is sure to have a major role to play.

AN INCREASINGLY IMPORTANT ROLE

More importantly, we are seeing increased attention being given to quality assurance as a whole. In the post-pandemic world, as agile mindsets rapidly become the norm, as IT is modernized, and as environments move to the cloud, people are growing more aware of the importance of quality and quality validation. As a result, we are witnessing a shift towards a more orchestrated approach to quality, not just across different industries, but across the board.

Quality assurance, or rather quality engineering, is a discipline that is maturing, and as you'll read in our executive summary, the excitement we have seen in recent years about the benefit potential of emerging QA approaches is giving way to greater confidence about implementation, and to a new and welcome sense of realism.

A TEAM EFFORT

This report wouldn't be possible without the significant contributions of many people. In particular, We must thank the senior industry figures whose insights have been used to illustrate our broader themes. I thank the 1,750 people worldwide who addressed this year's survey questions, and whose responses have helped us gauge prevailing moods and trends. I thank our partners at Micro Focus, and our own experts at Capgemini and Sogeti, who together have examined the survey findings and helped us to interpret them. We thank the report's production team: much work takes place behind the scenes to ensure this annual exercise bears fruit.

Finally, We thank you, our readers. It's your own experience and interest that give the World Quality Report its reason for being. As ever, We hope this year's edition makes a rewarding contribution to your continuing efforts in quality assurance.

SATHISH NATARAJAN

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

"This past year introduced new challenges to QA and IT strategy that affected nearly every area of business. The COVID-19 pandemic saw the convergence of digital transformation with the adoption of DevOps and Agile practices in real-time. Achieving digital transformation goals required the acceleration of hybrid work and the proliferation of application deployment across environments. Geographically distributed teams adopted a business-oriented focus while providing internal and external stakeholders business-critical, real-time data on any device, anytime, anywhere. Supporting these imperatives also required testing applications faster and earlier in the software development lifecycle (SDLC).

As our prior reports have noted, this year saw QA's continued adoption of Agile and DevOps practices. Driving this trend are artificial intelligence (AI) innovations and a growing culture of responsibility for quality across all teams. QA is becoming the key enabler—even the champion—of quality, not just the custodian. By providing the right tools and processes, QA can facilitate quality across teams and the SDLC. Some organizations are even starting to see dividends from these practices. Benefits include productivity improvements, higher software quality, and reduced quality costs. However, gaining success requires promoting a quality mindset, securing executive support, and fostering a culture of agility and adaptability.

During the year, customer experience rose in priority. Supporting pandemic-impacted requirements forced organizations to quickly supply new applications across new deployment methods. Achieving quality at speed was another top priority, which goes hand in hand with meeting business outcomes. As business priorities rapidly evolved, QA and IT teams required a quick and effective response to these needs.

Looking towards a post-COVID-19 environment, organizations shared their future priorities. The desire for remote access to test systems and environments illustrates the growing importance of SaaS and the cloud. Increasingly, organizations plan to use more AI in test execution activities, and almost half are willing to act on the intelligence of their AI and machine learning (ML) platforms. No longer a future initiative, leveraging AI and ML tools and processes is gaining steam with proven transformative benefits.

As QA trends evolve, Micro Focus helps customers advance their modernization initiatives. Our AI-powered continuous testing and quality management tools augment Agile and DevOps practices. Customers can speed up software production and delivery, all while enhancing software quality and security. With our tools and the right techniques, Agile lifecycles and DevOps pipelines can contribute to software quality. Organizations can improve quality, velocity, productivity, and the overall customer experience, across a range of web and mobile devices and environments.

One final note, I'd like to express my appreciation and thanks to our friends and partners at Capgemini and Sogeti, as well as to everyone who worked diligently to create this year's World Quality Report.

ROHIT DE SOUZA

Senior Vice President,
General Manager - ITOM Product
Group & ADM Product Group,
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EXECUTIVE SUMMARY

World Quality Report 2021-22

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A NEW REALISM

Last year's World Quality Report reflected the seismic shifts brought by the pandemic, as organizations adapted to operating completely remotely while still achieving effective business outcomes.

Some of the challenges facing organizations were new. Others were familiar, but they were happening at an unprecedented pace and scale. It was therefore good to be able to say that there were clear signs of energy, enthusiasm, and determination in the response of the quality assurance (QA) community to the crisis.

As the world emerges from what we must hope is the worst of the pandemic, we sense a change of mood. It's not that the optimism and the drive have diminished – because they haven't. It's rather that they have matured with experience. We might call it a new sense of realism. Last year, we asked if we can do it. This year, we know we can. It's a most encouraging thing

to see. In fact, we might say that what we're witnessing here is the comeback of quality assurance. Most CIOs now value testing more than ever before, and the onward march towards digitization is ensuring that customer experience and quality are of utmost importance
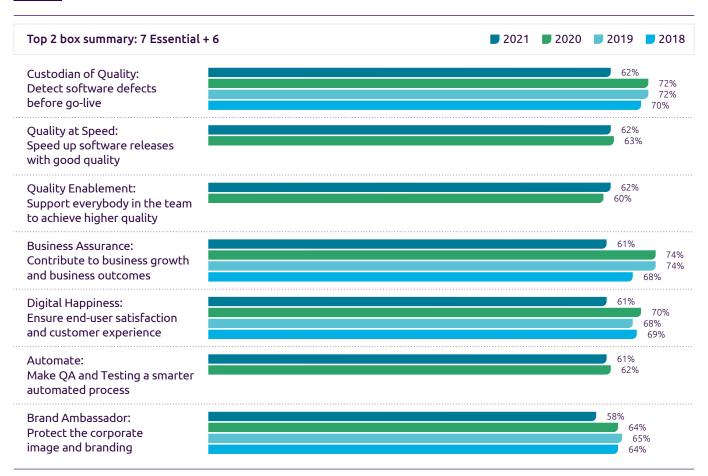
We see this evidenced in much of this year's survey data. Some of the high scores we've seen in previous years, especially in relation to emerging technologies and approaches, have flattened out to what seem to us to be more achievable or representative levels.

What respondents deemed to be the most important factors in their IT strategy have all dropped by several percentage points in the last two or three years; but between the top four responses, there was only a two-point spread. These were: enhancing customer experience (rated highly by 63% of respondents); enhancing security (62%); a higher responsiveness to business demands (61%); and higher quality of software solutions (also 61%). It makes sense that criteria such as these are so evenly weighted.

There is a similarly small point spread in people's assessments of the importance of their testing and QA objectives, in particular (see Fig 01). Custodians of quality, quality at speed, quality enablement across the team, business focus, customer experience, and more – all these goals are regarded in pretty much the same way. The overall sense that emerges is a positive one: that QA teams are focusing on value, and on avoiding the possibility of defects in the first place.

If anything, and because of this, we'd suggest that QA teams are more than the custodians of quality, and are its enablers and champions. Enabling or facilitating quality is dynamic; custodianship is passive.

Fig 01   Objectives of Quality Assurance and Testing in the organization

Top 2 box summary: 7 Essential + 6 — 2021, 2020, 2019, 2018

Custodian of Quality: Detect software defects before go-live
- 62% (2021)
- 72% (2020)
- 72% (2019)
- 70% (2018)

Quality at Speed: Speed up software releases with good quality
- 62% (2021)
- 63% (2020)

Quality Enablement: Support everybody in the team to achieve higher quality
- 62% (2021)
- 60% (2020)

Business Assurance: Contribute to business growth and business outcomes
- 61% (2021)
- 74% (2020)
- 74% (2019)
- 68% (2018)

Digital Happiness: Ensure end-user satisfaction and customer experience
- 61% (2021)
- 70% (2020)
- 68% (2019)
- 69% (2018)

Automate: Make QA and Testing a smarter automated process
- 61% (2021)
- 62% (2020)

Brand Ambassador: Protect the corporate image and branding
- 58% (2021)
- 64% (2020)
- 65% (2019)
- 64% (2018)

Organizations had mixed feelings this year about their ability to achieve their targets for applications development (see Fig 02). Nearly two-thirds of respondents (61%) felt their testing covers everything that's needed, and almost half (49%) said that end-to-end automation was always or almost always in place – but a higher proportion than last year felt their requirements are clearly defined, and, as you can see from the graphic, there was a substantial increase in numbers who felt that testing is optimized in terms of speed and cost. These higher figures suggest to us that people are seeking new ways of working. They're looking for greater and more effective flexibility, and more optimization on the fly. Looking across the responses as a whole, there is a clear sense that testing is no longer seen as a bottleneck.

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

Top 2 box summary: 7 Always Achieve + 6   ■ 2021   ■ 2020

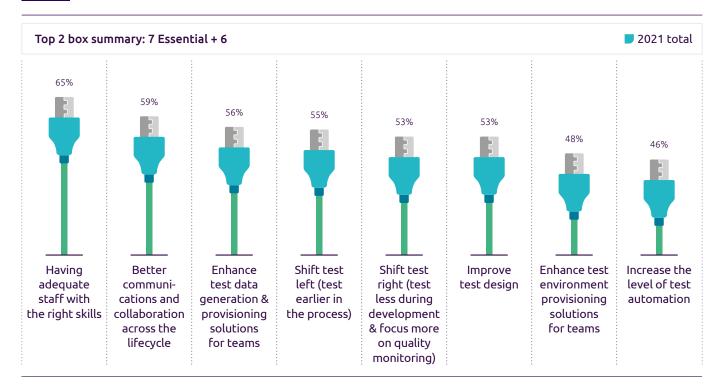| Our testing is complete (we cover all that is needed)	Activities across distributed teams are well orchestrated and integrated	Tools and methods required for test activities are sufficient and available	Requirements are clearly defined	Our testing is optimized in terms of speed and cost	End to end automation from build to deployment is in place
61% / 66%	59% / 61%	59% / 60%	53% / 50%	50% / 37%	49% / 56%

There were mixed feelings, too, about the ability of teams to achieve their testing targets for key applications. They were much less confident this year that they achieve their quality goals (59%), and they were less confident, too, that they have the right QA and test expertise (61%). However, substantially more of them felt they had the right testing strategy, process, or methodology: the figure of 59% who said this was the second-highest response, and it was significantly up from the 45% who said the same last year.

Perhaps here, too, we are seeing signs of the new realism. Last year, responses to this question were in a very narrow points spread, possibly indicating they were more focused on their immediate pandemic problems. This year, perhaps, they are taking stock more judiciously, and thinking again about the future, and not the here and now.

For the first time this year, we asked people to look ahead, and tell us where they thought they would be focusing their quality efforts in two years' time, compared to now. There was an upward trend in both acceptance testing and live in-production testing, collectively indicating an appreciation of the benefits of shift right. It's a push for prompt delivery that makes this shift happen, and as we can see in the Fig 01, quality at speed is consistent with other testing and QA objectives in terms of its perceived importance.

Testing efficiency is always top of peoples' minds, and we asked respondents to rate the factors that are critical for its achievement (see Fig 03). What's both interesting and striking is that the most important factor was deemed to be having enough staff with the right skills. In our view, it contributes significantly to the success of all the other options listed. We might have expected test automation to have attracted higher ratings, but the talent element is rightly the key.
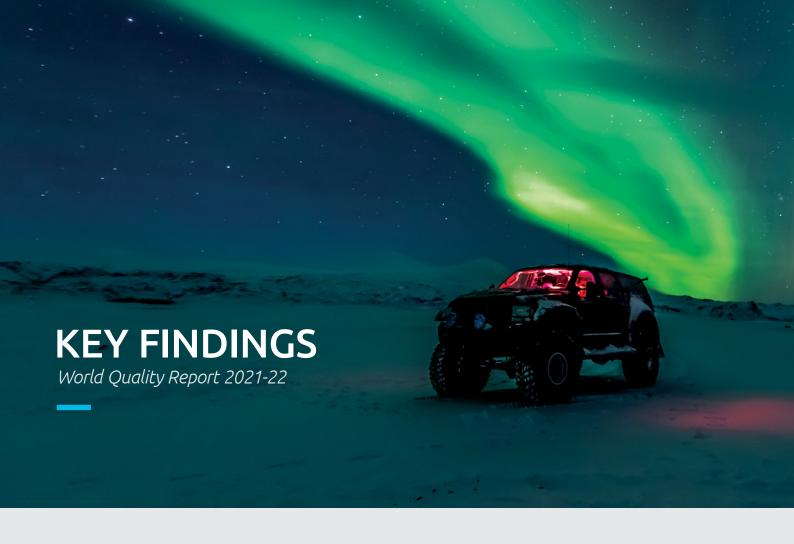
Fig 03 Importance of the following aspects towards making testing more efficient

Top 2 box summary: 7 Essential + 6 ■ 2021 total

65%	59%	56%	55%	53%	53%	48%	46%
Having adequate staff with the right skills	Better communications and collaboration across the lifecycle	Enhance test data generation & provisioning solutions for teams	Shift test left (test earlier in the process)	Shift test right (test less during development & focus more on quality monitoring)	Improve test design	Enhance test environment provisioning solutions for teams	Increase the level of test automation

To round off the top-line section of this year's survey, we asked organizations to take stock, and to rank the factors they felt would need most focus in the post-COVID environment. As we might expect in a world that has grown accustomed to working from home, the highest-rated option was remote access to test systems and test environments, and related factors such as improved productivity monitoring for remote teams and better collaboration tools also featured prominently. The security validation of applications and disaster recovery and resilience testing each received less attention, but we suspect this was because organizations feel these areas are pretty well addressed already. They are elements that are built into the system – and it's a system that has been through the fire, and is only now beginning to emerge from it.

We'll see how well the testing and QA community feels it's doing in more specific respects in the rest of this executive summary, and in the main report that follows it.

KEY FINDINGS

World Quality Report 2021-22

QA orchestration in agile and DevOps

The adoption of agile and DevOps in QA and testing is a continuing trend, and now that the world is beginning to emerge from lockdown, we see a greater sense of urgency to make progress, as well as a greater appetite for innovation. That said, though, organizations are at different stages of evolution, and some of them are not as far ahead even as their own managers think they are.

The greatest challenge remains a lack of professional test expertise in agile teams, which is partly the result of the blurring of boundaries across software development and test teams: when everyone shares responsibilities for quality, everyone's skills in that area need to level up, and collaboration between teams needs to improve.

In general, are agile and DevOps paying dividends? The short answer is yes: around two-thirds of respondents said they had achieved excellent or very good improvements in productivity, quality of software, and cost of quality. Speed to market was rated highly by fewer people. As we note in the main section for this topic, we may be seeing here a new test triangle of productivity, quality, and cost, in which productivity has replaced time in one corner.

The most striking shift we noted in the agile and DevOps area was a substantial drop from last year in the perceived importance of the technology stack of underlying applications. By contrast, the big risers were commercial priorities, the skill set, and the culture of the organization. What we're seeing here is the consolidation of the status of the business mindset and the growth of an industry-wide maturity in technical offerings.

Intelligent test automation

Organizations are as keen as ever on test automation. They want to automate faster, with greater quality, and with more agility – all of which means the approach needs to be smarter. This, in turn, means that the tools need to incorporate more intelligence, and also that more team members than ever need automation skills, often requiring an increase in recruitment to cope with the need.

As in previous years, this year we see around two-thirds of respondents identifying one of the key benefits of test automation as being the better control and transparency of their test activities. It seems people feel it improves the process of testing rather than its outcomes. Elsewhere, we noted a lack of confidence in some areas that the right automation strategy was in place.

Despite these challenges, respondents demonstrated a commitment to use automation techniques in a number of different ways in the coming year. Indeed, figures for planned use were up significantly compared to last year. Organizations feel that, while benefits in terms of outcomes may not yet have been fully realized, they are within reach, and that this is an area in which it is worth building a solid, strategic, skills-based foundation.

Artificial intelligence and machine learning

Artificial intelligence in testing has moved from something in the future to something we're witnessing currently in practice. It's gradually being infused into the QA process. For instance, it's changing the way test automation routines are built, and hence how testing as a whole is conducted.

It's not that the use of AI in quality engineering has fully matured just yet. There's still a long journey ahead. But what has changed is attitude: there seems to be a greater desire to put plans into action. Organizations seem keener to start their journey, even though change and maturity may still be required in terms of process, tooling, and general data integrity. Indeed, almost half of this year's respondents said thaty their organizations were willing to act on the intelligence their AI and ML platforms provide.

We noted a significant increase among those declaring a need for test strategy and test design skills. We feel this could be a sign that organizations are beginning to understand the intricacy of AI, and the challenges in taking advantage of it – as well as the difficulties of testing AI itself.

Finally, this year we see more respondents saying they plan to use AI in testing in more ways. The breadth of these plans, combined with people's confidence, may indicate the maturity of available solutions, and a growing confidence in their use.

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

We continue to see slow but steady progress in the development of test environment management (TEM) and test data management (TDM) this year. There has been a gradual shift of environments into the cloud, and this has introduced new challenges, such as ensuring that cloud-based apps remain in sync with legacy apps, and realizing that moving into the clouds can expose legacy decisions to fresh scrutiny.

Why has this shift been so gradual? It could partly be because in the move towards DevOps, there is a lot more focus on continuous deployment aspects than on continuous integration, where a lot of the environment virtualization or infrastructure-as-code skills and capabilities reside. It could also partly be because moving to the cloud is a big investment decision.

We've also seen the welcome growth in the ability of organizations to spin up test data and test environments on demand. We've seen increases in data masking and rationalization initiatives; we've seen growth in security initiatives, probably because of the numbers of people working remotely; and we've also seen test environments flex to reflect the new normal: for example, people want to look at data in different ways now.

In general, people are happy with the progress they're making, both with test environments, and with test data. There's no real cause for excitement here, but there are plenty of good reasons to be optimistic.

Intelligent Industry

Intelligent Industry is the term we're using at Capgemini for digital transformation that is largely in the physical world. It explores how organizations use embedded software, data, 5G, edge computing, artificial intelligence (AI), automation, and the Internet of Things (IoT) to rethink what they do, and how they do it.

People are still feeling their way in this area, which is why, we think, they gave roughly equal weighting to a wide range of factors they regarded as drivers for digital transformation. The greatest emphasis was placed on the benefits for which digital transformation is well known, including efficiency, quality, flexibility, and improved customer experience. To achieve these benefits, they're prepared to invest in team skills (rated highly by 55% of respondents) and in test tools (53%). The critical success factors were unsurprisingly deemed to be leadership support and funding (61%), and development of proofs of concept/pilots (also 61%). As we note in the main chapter on this topic, these are the priorities of organizations taking their first steps on a path: it's all about getting buy-in and demonstrating feasibility.

As many as 42% of survey respondents felt they would be upgrading their existing test labs with capabilities in 5G, IoT, AI, and autonomous systems. It seems they are confident they can accommodate these new technologies, but we're not sure how many of them appreciate the level of investment they may need to make.

This is the first year in which the World Quality Report has devoted a section to the Intelligent Industry, and so the only frame of reference we have for people's responses has been our own experience in the field. Next year, though, we will have this current analysis as a benchmark against which to assess 2022 responses and to identify trends.

KEY RECOMMENDATIONS

World Quality Report 2021-22

QA orchestration in agile and DevOps

Invest in insights.

Real-time insight across the whole QA and test function helps both with short-term tactical issues and longer-term planning of strategic direction. Smart dashboards are just one case in point.

Embrace multi-skilling and upskilling.

Software Development Engineers in Test (S-DET) is becoming a new normal, and is gaining widespread adoption. The path to that transformation is slow, but it's steadily increasing across all enterprises.

Adopt an engineering mindset.

An engineering mindset that is shared across your teams will pay dividends, including faster delivery.

Focus on what matters.

The emphasis should be on the customer experience and on business objectives, and on meeting needs in these areas with efficiency and speed. The focus is shifting from IT quality to production quality.

Intelligent test automation

Standardize the use of test automation in QA ...

An automation-first approach in software quality delivery should now be the norm.

... and use it from end to end.

Expand end-to-end lifecycle test automation across all QA activities.

Artificial intelligence and machine learning

Drive the use of AI. Don't be driven by it.
AI/ML is expected to deliver exponential improvements in overall test productivity – but you need to ensure you're using the information it provides as a support in your own decision making. It's not relieving you of that responsibility, nor should it.

Focus AI efforts on what matters.
Invest in AI solutions with use cases that are targeted to the most challenging aspects of quality delivery.

Stop talking, and start doing.
AI and ML are expected to transform quality engineering, so it's imperative to start the journey now.

Consider using AI as part of overall QA management.
AI needs to be there to support the management and decision making around QA. Tactically, it can help to make sense of what to do, when to do it, and sometimes when not to. Strategically, it can help organizations to understand why failures are happening, and not just to identify them.

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

Emphasize availability.
Investment in real-time environment and data availability solutions should continue to be a focus within the organizational strategy.

Don't let the future obscure the needs of the present.
Cloud adoption is continuing to grow, but ensuring integrity with legacy applications is crucial.

Factor in data analytics.
Data analytics is now a prominent aspect of the test data management framework, beyond dynamic test data generation, and subset and masking approaches.

Intelligent industry

Invest in the future …
Invest in innovation labs to build minimum viable products (MVPs) and to derive value swiftly.

… and in your teams
Your QE teams will soon be the source of rapid growth in Intelligent Industry. It's worth expending time, energy and budget here.

Increase the focus on security.
Greater remote connectivity creates a need for greater security and resilience. This, in turn, has implications for testing and QA.

Get management buy-in.
It's a given that leadership backing facilitates change – so demonstrate feasibility and quantify potential outcomes.

TAKING STOCK OF THE SUMMARY

As we've seen, a new and welcome sense of pragmatism has been become apparent in testing and quality assurance this year, as the world starts to emerge from the global pandemic. Expectations are, in general, more realistic, and key areas of IT strategy such as enhancing customer experience, enhancing security, responsiveness to business demands, and high quality of software solutions are being given broadly equal weight.

Testing and QA objectives are also pretty evenly balanced: acting as custodians of quality, achieving quality at speed, enabling quality across the team, focusing on business outcomes, and improving customer experience are largely regarded in a similar light to one another.

Looking across the software development lifecycle as a whole, there a clear sense that testing is no longer seen as an obstacle to progress, but as a factor in its achievement. Expectations of a shift to the right are a part of this, because implicit in this shift is a push for prompt delivery.

A distillation of current trends

QA orchestration in agile and DevOps:
General progress is being made in these development environments, and there is a clearer focus than ever on the importance of business outcomes.

Intelligent test automation:
There are signs that organizations feel test automation is still improving the process of testing rather than its outcomes, but they are as keen as ever to achieve more, and they are developing strategies and skills to get themselves there.

Artificial intelligence and machine learning:
Smart technologies in QA and testing are no longer in the future – they're arriving. Confidence is high, plans are robust, and skills and toolkits are being developed.

Test environment management and test data management:
Progress here has been slow but steady, particularly in the shift of test environments to the cloud. We've seen a growing ability to spin up test data and test environments on demand, and in general, organizations seem happy with their rate of progress.

Intelligent industry:
Organizations are keen to achieve the digital transformation in the physical world, and to realize obvious benefits including efficiency, quality, flexibility, and improved customer experience. To get there, they recognize they're going to need management buy-in – and to get that in turn, they're going to need to demonstrate feasibility.

Keep learning – and keep moving forward

Finally, and as in previous years, so this year: there is an acknowledged need to develop new skills, and to extend existing skills across more of the software development and test team.

Will this skills gap ever disappear? In our view, we should all hope not: it's the desire to know more and to achieve more that drives us all forward. It's incumbent on all of us in the testing community to grow in knowledge, to maintain our momentum, and to keep the QA comeback on course.

CURRENT TRENDS IN QUALITY ASSURANCE & TESTING

QA orchestration in agile & DevOps

Getting down to business

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Director Financial Services, Capgemini, United Kingdom

HITESH PATEL
Region Practice Manager, DA&QE, Sogeti USA

UDI WEINBERG
Director of Product Management,
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WOUTER RUIGROK
Agile Quality Coach, Digital Assurance & Testing, Sogeti, NL

> *We're seeing a huge culture shift. Just as in our daily lives, where everyone wants and expects next-day or same-day order fulfilment, so in business, people want their code to be delivered immediately, and good-to-go. This is why we're seeing a move toward continuous testing, where we're aiming to prevent defects, rather than find them. It's a new mindset, in which quality assurance is no longer a separate and distinct discipline, but is merging into the overall software development process.***"**

BRANDY FITZPATRICK
Vice President , Quality Management Office,
Fifth Third Bank

It's the size and scope of the annual survey on which it's based that gives this World Quality Report such substance. Quantitative analysis is a powerful thing. However, as we all know, there is much to be said for qualitative analysis too, which is why it's so interesting to read the opinions and experiences of the senior executives we quote throughout this year's report.

To all this, we can add our own preliminary observations. For instance, in last year's report, it was noted that the adoption of agile and DevOps was evolving steadily, rather than undergoing a major revolution. We now suspect that this steady evolution was a product of the circumstances in which we were all living. Uncertain times prompted caution – and that was a shame, because in hindsight, the hiatus provided a great opportunity to pause, reflect, and to consider new courses of action.

However, since then, people and organizations have to some extent reorientated themselves to pandemic and post-pandemic living. As working from home becomes more routine, and as vaccination programs achieve scale, we can see things start to change. We sense the market is opening up. Some organizations are growing less conservative. They are finding an appetite to innovate, and their skills requirements are growing as a result. We see a widening gap between those who are blazing the trail in agile and DevOps adoption and those others who are just starting out. Indeed, we're even seeing some organizations making conscious decisions not to make the move just yet at all, simply because they perceive no immediate need. Likewise, we sense a mismatch in some other perceptions of the extent to which organizations have indeed adopted agile development practices: managers may think they are running agile shops, but their teams may not see it that way.

Incidentally, it's hard to gauge the extent to which working from home will continue as the world emerges from lockdown. In a world of increasing agile and DevOps adoption, where teams are rounding out their skills, and the old boundaries between development and test are blurring, we feel a hybrid approach will be facilitated, and will therefore be more likely. If this happens, we can expect to see developments in both the functionality of, and the adoption of, reporting tools and of collaboration tools, because remote working will make these changes necessary.

Growing challenges

Given our qualitative impression that momentum is starting to build, it was interesting for us to see the extent to which our observations were borne out in this year's quantitative survey data. If things are indeed now starting to move, what are the main challenges organizations are facing in applying testing to their agile developments?

The challenge attracting the greatest response – 44% of our respondents – was a lack of professional test expertise in agile teams. This may at first sight seem puzzling, especially as we notice that responses for this survey option have been slowly growing since 2018. But it's worth recalling that one of the principles of the agile methodology mindset is the blurring of boundaries between the hitherto distinct disciplines of development and testing. Quality assurance is a skill that, increasingly, all agile team members need to have, and we may be seeing that reflected here in this perception of a growing need for test expertise. Skills enable teams not only to identify risks, but to use appropriate quality measures to deal with them.

Indeed, our regular skills question in this section of the report shows growing perceptions of knowledge gaps across all skills types. One of the biggest risers, with 31% noting a need, was test environment, containerization and test data skills. Similarly, a high number of respondents (41%) earmarked the difficulty not of skills, but of getting the right test environments and test data in the first place. This is a perennial challenge for organizations, which is why we devote a regular section to it each year in this report.

There was a substantial rise this year in the proportion of respondents reporting difficulties in automating test activities – up to 36% this year, from 27% last year. We suspect this may be a downside to the blurring of disciplinary boundaries: the teams may be moving towards multi-skilling, but it increases the likelihood that they work in siloes, leading to struggles with frameworks, with libraries, and with tool alignment. It may also be the result of the increasing number of automation assets and pipelines, and the challenge to maintain automation on a large scale. Automating a single flow may not be a technical challenge any more, but running hundreds and thousands of tests is a challenge in itself.

> *Now that we're moving towards quality being the responsibility of entire agile teams, we're seeing a greater understanding among developers of what it takes to conduct truly effective tests of code. Before, developers and QE people didn't understand the workload implications of one another's tasks – but now, they all work together, so the understanding is better. They can see what the consequences of an action will be on other parts of the process. It's a really positive change.*

GERI DUFFY
Applications Engineering Director, Commercial Lines,
American Family Insurance

Acceleration and optimization

We asked our respondents to look ahead a little, and to tell us how likely they were to use a range of different approaches to speed up and optimize their testing in agile and DevOps environments (see Fig 04).

Year on year, what's interesting here is that things are levelling out. Last year, the gap between the most and least popular options was 17 points; this year, everything falls within a five-point range. It seems that pretty much equal weight is being given to all these approaches.
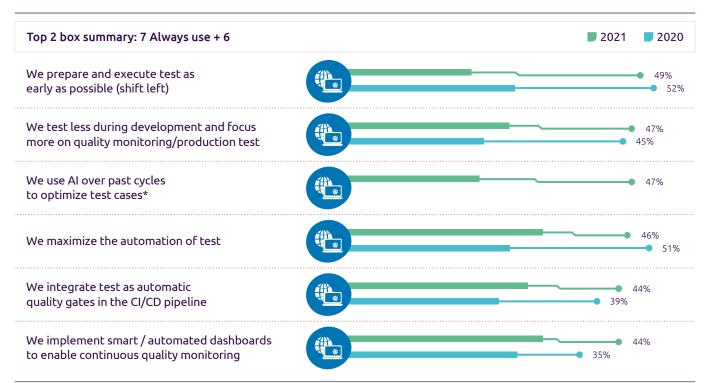
The biggest riser on last year is in the projected use of smart or automated dashboards, which was given a high rating by 44% of respondents, against 35% last year. Dashboards provide a single view of quality, and we do see their increasing use in the field. This is probably partly because more organizations are focused on quality monitoring and not on testing, so they need good, online, dashboards that can reflect the status at any given time. It's also partly because they simply feel they need more insight.

By contrast, the number of respondents saying they are likely to maximize test automation has dropped since last year. We see this not so much as a technical challenge, as a practical one: the sheer volume of work can be a problem.

A new option this year was the use of AI to optimize test cases. Almost half our respondents (47%) rated this as likely, which seems high to us. With the exception of some sectors, including financial services, revisiting past cycles is less of a factor.

This is, in short, a slide that is capable of several interpretations, and so it's worth recalling a couple of things. First, our survey sample this year is drawn from a broader pool than previously. For example, it includes more engineering organizations, and more high-tech startups, both of which may affect the figures. Second, this is of course an aspirational question. We are asking people here how likely they are to use these approaches, and not whether they are already doing so. It will be interesting to see if aspiration is matched by practice in years to come.

Top 2 box summary: 7 Always use + 6   ■ 2021   ■ 2020

Approach	2021	2020
We prepare and execute test as early as possible (shift left)	49%	52%
We test less during development and focus more on quality monitoring/production test	47%	45%
We use AI over past cycles to optimize test cases*	47%	
We maximize the automation of test	46%	51%
We integrate test as automatic quality gates in the CI/CD pipeline	44%	39%
We implement smart / automated dashboards to enable continuous quality monitoring	44%	35%

New option introduced in 2021 study

Improvements and indicators

We didn't just ask people to look ahead. We also encouraged them to take stock of where they are now. In a new question this year, we asked how much improvement they thought agile and DevOps had delivered. Around two-thirds of them (67% to 69%) said they had achieved excellent or very good improvements in productivity, quality of software, and cost of quality. Speed to market was rated high by fewer people (64%). We may be seeing here a new test triangle of productivity, quality, and cost, in which productivity has replaced time in one corner.

What was notable this year was the frequency with which respondents said they were using various indicators to track the quality of their applications. In almost every category of metric, including requirement coverage by test, test velocity, defect density, and defect leakage into production, the number of organizations saying they often used the approach had risen significantly on last year. We see this as a good sign: they are clearly focused on fixing things, and the fact that more aspects of quality are being measured now suggests testing in an agile environment is maturing. It's perhaps also a sign that testing and quality in agile is not just at team level, but that higher managerial levels are also looking at the data, and tunning their metrics and KPIs to reflect that.

Business first

Without question, the most striking slide for us this year in relation to agile and DevOps adoption was in relation to what our respondents deemed to be the most important factors (see Fig 05).

Just look at it: the number of all respondents who gave weight to the technology stack dropped 16 points from last year, to 49%, while the big risers were business priorities and the culture of the organization, including organizations' openness to the adoption of change.

What we're seeing here is a major realignment. Now more than ever, organizations are recognizing that the needs of the business are more important than the underlying technology, or the environment, or anything else, and that new skills and a new mindset are required. They seem to be seeing that the destination is more important than the route they take, or the vehicle in which they travel – and that has to be very good news indeed.
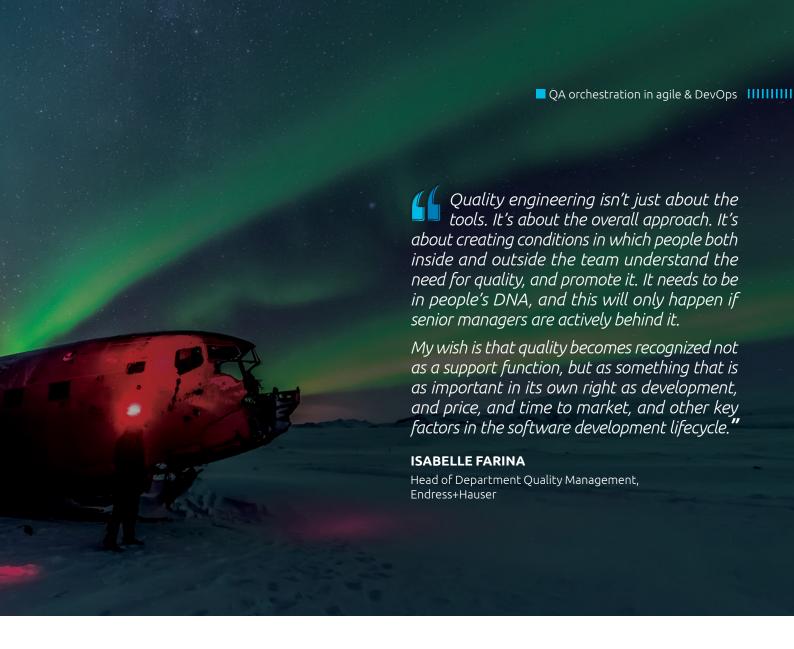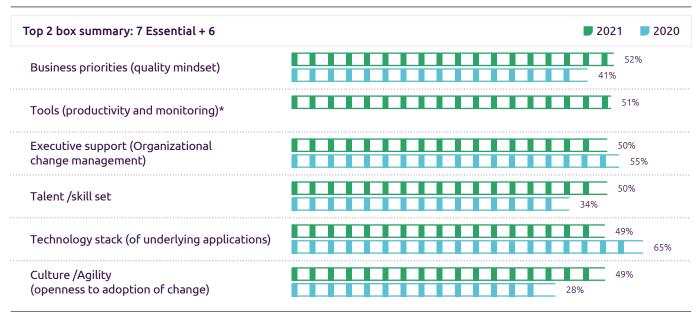
“ *Quality engineering isn't just about the tools. It's about the overall approach. It's about creating conditions in which people both inside and outside the team understand the need for quality, and promote it. It needs to be in people's DNA, and this will only happen if senior managers are actively behind it.*

My wish is that quality becomes recognized not as a support function, but as something that is as important in its own right as development, and price, and time to market, and other key factors in the software development lifecycle.”

ISABELLE FARINA
Head of Department Quality Management,
Endress+Hauser

Fig 05   Importance of the following aspects for successful Agile and DevOps adoption

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Top 2 box summary: 7 Essential + 6 ■ 2021 ■ 2020

Business priorities (quality mindset)
52%
41%

Tools (productivity and monitoring)*
51%

Executive support (Organizational change management)
50%
55%

Talent /skill set
50%
34%

Technology stack (of underlying applications)
49%
65%

Culture /Agility
(openness to adoption of change)
49%
28%

New option introduced in 2021 study
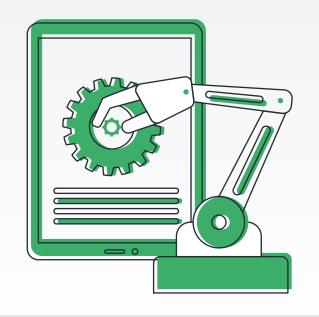
21

Test automation

Great expectations

> " *Automation increases thoroughness. When tests are all manual, there's a temptation to skip some phases, because the effort doesn't seem worth the outcome. But when they can be automated, there's no need to skip them.*
>
> *It's also important for us to utilize our data, to make the insurance quote process better. There is so, so much data! And so, using technology to aggregate it can help our agents formulate quotes. We're still in the early stages, but it saves them time, and it means our commercial customers get faster quotes, too.* "

GERI DUFFY
Applications Engineering Director, Commercial Lines, American Family Insurance

MARCO VENZELAAR
Managing Consultant & Lead Technologist, Sogeti, United Kingdom

APPAJI KUMBHAR
Test Automation Lead, Sogeti Sweden

JEFFREY SMITH
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AYAL COHEN
Senior Director, Product Management, Application Delivery Management, Micro Focus

RIZVAN SAIYED
Program Manager, Capgemini

RAJESH NATARAJAN
Director, Digital Assurance & Quality Engineering, Sogeti, North America

A great deal can change in the course of a year, and especially in any area in which technology plays a part. When we looked at test automation in this report last year, the trends we noted included mixed messages about perceived benefits, various skills gaps, signs of overoptimism, and a general sense of progress being made.

And this year? Yes, well, as we shall see although there has indeed been some movement, nothing much has changed in all the respects listed above. Sometimes – and this is one such instance – the very lack of a change can itself be interesting.

Faster, better, nimbler, smarter

Before we look at this year's survey results, it's worth taking stock of what we're seeing in the field. Our roles give us insights into the experiences and practices of many enterprises in different sectors worldwide, and we've been sensing an appetite for major developments in test automation. Many organizations need to automate faster, with greater quality, and with more agility – all of which means the approach needs to be smarter.

Implicit in these automation demands is the need for greater resources, and in particular for more people. There are two ways in which this might be addressed. First, and obviously, greater efforts than ever should be made to increase the size of the pool with the requisite technical skills. Second, and perhaps less obviously, approaches to automation can be adopted for which scripting skills aren't necessary. This second course of action can

be described as intelligent automation, and its attractiveness lies not just in the reduced need for technical knowledge, but in the fact that it opens test automation to people who can bring more of a business focus to the task. After all, the more closely aligned the means are to the end, the greater the likelihood of a better outcome.

The application of automation – and questions of confidence

One of the best places to start in our detailed assessment of the current status of automation is to gauge the extent to which it is being used across a spectrum of different test activities. As in previous surveys, so this year we see that in general, an average of between 15% and 20% of tests are being automated. It's a difficult area to measure, because organizations tend to have different KPIs, but the survey data indicates that activity types include user acceptance tests, and test data generated by test data tools. Regression testing appears within this 15%–20% band, and although this marks a four-point rise on last year, we were nonetheless surprised it wasn't higher – it's an obvious candidate for automation.

Overall, it's hard to tell whether the figures have been influenced by a range of factors, including the seniority of the respondents, whether the adoption of agile or DevOps has changed organizations' approaches, and how individual activity types have been interpreted in answering the question.

We see seeming contradictions in a question that assesses the confidence of respondents in their automation approach and also in their capacity for it. How true, we asked them, are each of the following statements for you? The option that attracted the most positive response was, "We have the required automation tools," while the option that attracted the fewest positive responses was, "We have the right automation strategy." There may be no contradiction here after all. It may be that people feel they have chosen the right tool, but maybe not the right approach to automation, or they may not have the right skills for the right testing phase. It's crucial to formulate the right automation strategy in order to set everybody's expectations and to be able to measure the benefits properly.

One of the most noticeable responses was in relation to the statement: "We have enough time to build/maintain the automated tests." In 2020, almost two-thirds of respondents (63%) gave this a high rating – but this year, that figure had dropped to under half (48%). Several factors may be at work. If we make regional comparisons, we can see big differences here. North American respondents continued to support this statement in large numbers (61%), but the global average is reduced by other regions, including South-East Asia and parts of Europe. And if we make sector comparisons, we see high numbers of people in telecoms and consumer goods supporting the statement (67% and 56% respectively), but far fewer in other verticals, including energy and utilities, transportation, and the public sector. To explain the overall drop, we clearly need to understand what is going on in these individual areas.

> *It's often said that QE teams need more people. That's not always the case. What teams do need is the ability to do more, and to do it better, and that doesn't always mean a higher headcount. It can mean better skills. And it can mean better tools, for instance, such as intelligent test automation – and the skills with which to use them. These skills can be hard to find."*

ISABELLE FARINA
Head of Department Quality Management,
Endress+Hauser

Benefits and skills

In the introduction to this article, we noted that last year there were mixed messages on perceived benefits. The same is true this year, although in different ways. For example, there has been a big jump in the number of people who agree that they get ROI from their automation efforts – from 37% last year, to 50% this year. We find this surprising, because it's not what we see in the field.

The disparities continue in responses to our main question on automation benefits (see Fig 06). 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, we see that perceived benefits are down year on year in every case. Last year, they were all up. The differences aren't great, but they're interesting. The new option at the top of the graph, relating to the benefits of the use of AI and machine learning (ML), seems high to us.

Stand back a little from those left-hand bars, though, and a more basic trend becomes apparent. There are fluctuations in values across each benefit type, but the one that has been consistently higher over the last four years is at the bottom of the graph. Year on year, around two-thirds of respondents (63%–69%) perceive the benefit of better control and transparency of their test activities. It seems, therefore, that automation is being deemed to improve the process of testing rather than its outcomes.

In short, it's clear that the benefits of automation have not yet been fully realized.

In the bars on the right, we see that the benefit for which there has been the greatest increase since last year in perceived value is in relation to security, with a benefit value of 18% in 2020 rising to 24% in 2021. The effect of COVID on the online business and consumer worlds may be a factor here.

Fig 06   Benefits realized from Test Automation

Yes Summary	2021	2020	2019	2018	2017	2016	2021 Benefit value %	2020 Benefit value %	2019 Benefit value %	2018 Benefit value %	2017 Benefit value %	2016 Benefit value %
Usage of AI/ML for dynamic scope selection etc.*	52%						**Benefit value % not asked**					
Better detection of defects	49%	57%	56%	64%	60%	42%	20%	20%	21%	18%	19%	22%
Reduction of Test Cycle Time	52%	65%	54%	64%	54%	39%	21%	19%	21%	18%	19%	21%
Reduction of overall security risk and security related issues in code	51%	62%	53%				24%	18%	**Benefit value % not asked**			
Better Test Coverage	47%	58%	68%	51%	40%		22%	20%	**Benefit value % not asked**	18%	19%	19%
Reduction of Test Costs	47%	62%	56%	61%	53%	39%	20%	19%	21%	16%	20%	20%
Better control and transparency of test activities	68%	69%	63%	66%	43%	38%	22%	**Benefit value % not asked**	**Benefit value % not asked**	18%	19%	19%

Preparing for the future

We also noted in our introduction that last year we reported various skills priorities. It will come as no surprise to anyone to hear that the same is true this year – but the difference is that the numbers for every skills option have risen markedly. For example, the importance of skills in AI and machine learning was rated highly by 26% of respondents in 2020 – and by as many as 56% this year. Could the buzz around smart technologies be a factor here?

The skills area which the fewest people rated important (51%) was test automation architecture skills. If we look back at the benefits graph, we see that this score runs counter to the relatively high perceived benefits in control and transparency. We'd expect the importance of these automation architecture skills to be higher. It's puzzling, and possibly worrying. If the foundations (the architecture, the approach, the strategy) are not in place, or are wrong, substantial benefits will never be achieved. Worse still, the image and the implementation of test automation could be damaged.

Our final question in this section asked respondents which automation techniques they envisaged their organizations would be using this year (see Fig 07).

Once again, we can see that scores in general are up significantly this year, and that new options such as self-healing and low-code/no-code automation are in line with these increased levels. It may simply be that this slide indicates wishful thinking, and that everything is being deemed to be a priority, including model-based testing, where we see a lot of interest in the field.
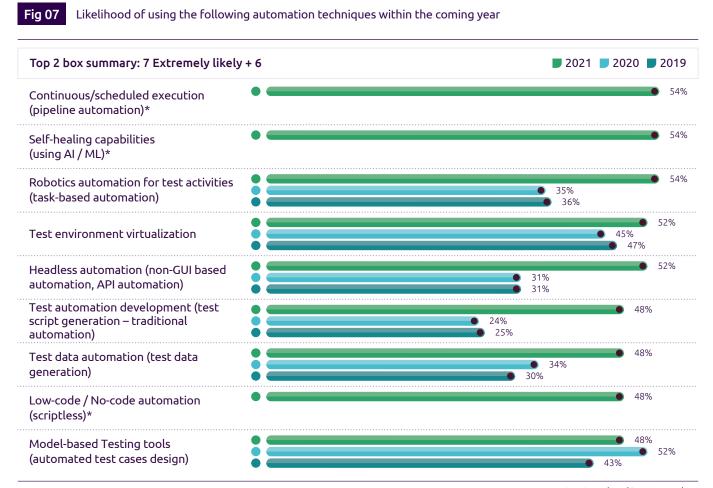
The positive thing to take away from these figures is that they indicate optimism. Although, as we have seen, organizations don't feel they are getting sufficient benefits from test automation right now, they do feel this is an area in which it's worth investing – and indeed, that investment is something we're seeing in the field.

It will be interesting to see if these investments continue, and if they bear fruit. Like so many other areas of technology, test automation has been the victim of hype, and so there is a need for pragmatism. The old saying is true: there is a big difference between doing the right things, and doing things right – and in this case, doing things right means ensuring they are aligned to the needs of the business, building on a solid, strategic, skills-based foundation so that all the other benefits from automation can be achieved.

> *In the early days, our driver was how much we automated. It was too simple a metric: it was a number, but not a value. It was an approach that didn't necessarily deliver the best outcomes. Nowadays, we know better. We know we need to prioritize in terms of both quality and quantity. So if I could go back and talk to myself and the team in those early days, one thing I'd tell everyone is to trust the test automation experts to know what the real success metrics should be. And the most important thing I'd say is this: "Automate what's valuable."*

JOSÉ JIMÉNEZ
SAP test management lead JTI

Fig 07   Likelihood of using the following automation techniques within the coming year

Top 2 box summary: 7 Extremely likely + 6   ■ 2021   ■ 2020   ■ 2019

Technique	2021	2020	2019
Continuous/scheduled execution (pipeline automation)*	54%		
Self-healing capabilities (using AI / ML)*	54%		
Robotics automation for test activities (task-based automation)	54%	35%	36%
Test environment virtualization	52%	45%	47%
Headless automation (non-GUI based automation, API automation)	52%	31%	31%
Test automation development (test script generation – traditional automation)	48%	24%	25%
Test data automation (test data generation)	48%	34%	30%
Low-code / No-code automation (scriptless)*	48%		
Model-based Testing tools (automated test cases design)	48%	52%	43%

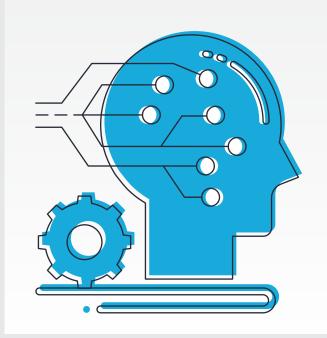*New options introduced in 2021 study*

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Artificial intelligence and machine learning

Smart testing: the future's getting closer

> *When we introduced AI to the process, we used it for optimization – for instance, in identifying areas of needless duplication that we could address. Since then, we've started to use it in more sophisticated ways. AI helps us to see what's changing with each rev, so we can figure out what to test, and build the test suite that this implies.* **"**

ANAND DEVANATHAN
Director, Digital Assurance & QE, VMware

ALBERT TORT
Chief Technology Officer, Sogeti Spain

JEFFERY SPEVACEK
Director, DA&QE Practice Leader – Financial Services

AYAL COHEN
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SAI GRANDHI
Director, Digital Assurance and Quality Engineering, Sogeti USA

In last year's World Quality Report, the mood surrounding the use of artificial intelligence (AI) and machine learning (ML) in Quality Engineering (QE) might best be summarized as one of cautious optimism. Expectations were running high, new use cases were emerging, AI was a key criterion in tool selection, and our respondents saw it as a growth area.

However, possibly because of the pandemic, and possibly because of skills gaps, the technologies did not reach a mature stage of adoption. There were signs instead of greater emphasis on test automation, where earlier paybacks might be anticipated. It was, to some extent, a waiting game.

A year has now passed – and we've witnessed a significant shift. Artificial intelligence in testing has moved from something in the future to something we're witnessing currently in practice.

For example, we're seeing that AI is changing the way test automation routines are built, and hence how testing as a whole is done. Specifically, it's helping with the development and maintenance of automation scripts, introducing an element of scriptless automation and self-healing. The application of AI in this area is reducing cycle times and improving speed to market.

In addition, AI is increasingly being used to remove duplicate and redundant cases in test suites; defect prediction in test models is growing as an AI application area; and AI analytics are helping with basic principles, such as defining what needs to be tested, how to define quality, and how to execute test routines so the desired quality can be achieved.

It's not that the use of AI in quality engineering has fully matured, because it hasn't, not yet. There's still a long journey ahead. But what has indeed changed is attitude; there seems to now be

more of an inquisitive curiosity and desire to put practice into action. Organizations seem keener to start their journey, even though change and maturity may still be required in terms of process, tooling and general data integrity.

General confidence – and use case trends

All this, at least, is the mood we sense from organizations in the sectors and regions with which we have regular contact. But to what extent are these observations corroborated by this year's survey data?

In response to a new question in this year's survey (see Fig 08), it was intriguing to note a certain level of general confidence. Almost half of the QE, testing, and apps managers and VPs we questioned (48%) felt they had the established repository of test execution data that AI and machine learning require, and almost as many (46%) said their organization was willing to act on the intelligence their AI and ML platforms provide. In the first case, we feel that while data repositories may be well established, the integrity may well be low – a feeling that seems to be corroborated by the bottom lines of the chart, where we see only 39% of respondents said they had confidence their data repository is correct and accurate, and 41% said they trust the intelligence that AI and ML provide.

In the second case, we expect that the degree to which organizations are willing to act on AI-derived recommendations is conditioned by circumstances, and could in some cases be

higher. For example, they may indeed act on duplications identified in automation script routines, but this is essentially what we might term an offline function. By contrast, in live scenarios – for instance, in financial services applications, where acting on an AI or ML recommendation could have significant commercial implications – we sense there is a greater degree of apprehension.

There have been some shifts in use cases since last year. In 2020, 30% of respondents said risk-based testing or test prioritization were highly relevant, and this year that figure jumped to 43%. It's a trend we've seen in the field, and it's a welcome one. By contrast, the reported relevance of automated root cause analysis has dropped year on year from 58% to 49%. It's an important application area for AI, and this is a big drop.

Perhaps we can read between the lines a little here. Alongside risk-based testing on 43%, the other significant risers this year were fit-for-purpose test environment provision (44%) and defect prediction (42%), with the new option of fit-for-purpose test automation at 43%. This could be an indication of greater DevOps adoption, and the need to automate and accelerate the process of testing – slowly converting manual processes that rely on human intuition into systems managed by an AI/ML platform.

In addition, all these use cases have specific calls to action. For instance, fit-for-purpose test automation and defect prediction are important in agile environments as part of a busy software development and test cycle. But automated root cause analysis looks down the road a little. If respondents are more focused on the here-and-now, the drop is in this case perhaps understandable.

Fig 08 AI/ML testing readiness in the orgnazation

Top 2 box summary: 7 Strongly agree + 6	■ 2021 total

48%	46%	42%	42%	41%	39%
We have an established repository of test execution data required by AI/ML platform	My organization is willing to act on intelligence provided by the AI/ML platform	Business owners trust the intelligence provided by the AI/ML platform	I have identified applications/ programs that have a need/ benefit from AI/ML	Application owners trust the intelligence provided by the AI/ML platform	I have confidence that my test execution data repository is correct and accurate

AI and skills needs

There are also several year-on-year changes in perceived skills gaps. When asked about the extent to which artificial intelligence changes the skills needed from QE and test professionals (see Fig 09), there was a significant increase among those declaring a need for test strategy and test design skills. This, we feel, could be a sign that organizations are beginning to understand the intricacy of AI, and the challenges in taking advantage of it – as well as the difficulties of testing AI itself. With AI – and with NLP, too – people who don't have scripting skills can take part in the test automation game.

The biggest increase, however – a rise of six percentage points on last year – was in the perceived need for test data set-up and generation skills. We believe this may reflect the increasing extent to which agile and DevOps methodologies are being adopted.

Interestingly, the figures also show a distinct trend in terms of the understanding of the effect AI has on business processes. The perceived skills gap here shows a three-point drop each year since 2019. This may encouragingly indicate that testers are growing more business-savvy, and that they better understand the commercial implications of their work.

> *The use of AI in quality assurance and testing is likely to grow, because the workload is also growing, and smart tools and methods will help. But we'll also need people to be familiar with those tools, and to have knowledge that isn't just broad, but deep, too.*
>
> *That said, though, AI won't solve everything. You'll always need good people.*
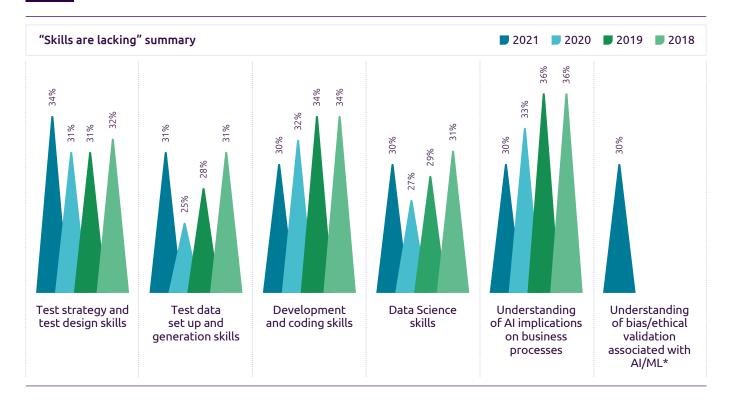
ISABELLE FARINA
Head of Department Quality Management, Endress+Hauser

This year, a new option was introduced to this survey question. Almost a third of respondents (30%) saw a skills requirement in the understanding of the implications of AI in terms of bias and ethical validation. It was one of the lowest-scoring responses to the skills-gap question, and we expect it to decrease as people grow in experience, and as the technology becomes more mature.

Fig 09   Extent to which artificial intelligence changes the skills needed from QA and Test Professionals

"Skills are lacking" summary — ■ 2021 ■ 2020 ■ 2019 ■ 2018

	2021	2020	2019	2018
Test strategy and test design skills	34%	31%	31%	32%
Test data set up and generation skills	31%	25%	28%	31%
Development and coding skills	30%	32%	34%	34%
Data Science skills	30%	27%	29%	31%
Understanding of AI implications on business processes	30%	33%	36%	36%
Understanding of bias/ethical validation associated with AI/ML*	30%			

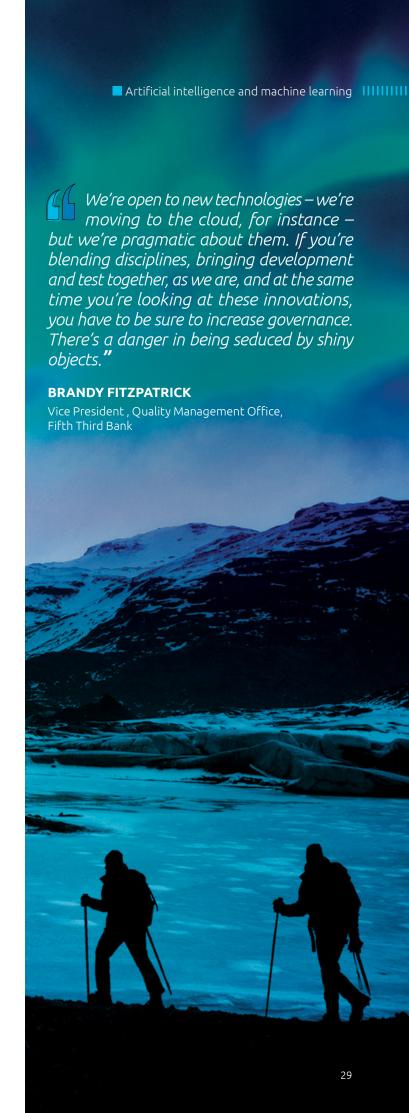## Testing strategies – and looking ahead

What effect is the use of AI having on overall quality and test strategy? A full three-quarters of our respondents (75%) noted the need for new test strategies, and acknowledged that the use of AI in testing changes those strategies. It's a sign, we feel, that organizations are adapting to ensure they achieve the best value from their efforts. We've seen this in the field – in the financial services sector, for example. Also, implicit in the perceived need for changes to strategy is the common uncertainty about the risks associated with signing off on not covering all bases by executing every possible test run. Artificial intelligence can change strategy by providing insights to make that judgement call with greater confidence.

For the first time last year, we asked people to rate options in their plans for AI and testing. There were some differences then – but this year, it's notable that three-quarters of people (75% and 74%) gave high scores to all options. For example, respondents said they would be taking advantage of AI technologies to build self-healing test automation; that AI will be used to generate test environments and test data; and that they will be using more AI-powered dashboards. The robustness of these plans may indicate the maturity of available solutions, and a growing confidence in their use.

Our last AI-related question this year was a new one: which software testing tool type, we asked, would benefit the most from AI and ML functionality? The highest-rated option was performance test automation, which was selected by almost a quarter (23%) of respondents. This, for us, is in line with core business expectations of quality. After all, slow app responses and other instances of poor performance can do damage to a brand, and in cases such as in the finance sector, could result in significant losses.

Other testing tool areas highlighted by our respondents as standing to benefit from AI included functional test automation (17%) and mobile test automation (14%). These, too, are important areas, and the lower ratings they were given here may be an indication that adoption of AI and ML functionality is already progressing in these tool types. In the field, we're seeing different rates of adoption in different vertical sectors.

It seems that here, and in many other areas indicated by this year's survey results, our initial observations have been corroborated. In short, we're seeing organizations keen to put AI and ML techniques to good use in their quality assurance programs. This is an area we shall continue to monitor – because the future is becoming ever more part of the present.
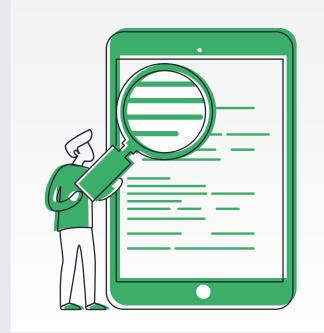
"We're open to new technologies – we're moving to the cloud, for instance – but we're pragmatic about them. If you're blending disciplines, bringing development and test together, as we are, and at the same time you're looking at these innovations, you have to be sure to increase governance. There's a danger in being seduced by shiny objects."

BRANDY FITZPATRICK
Vice President , Quality Management Office,
Fifth Third Bank

Test environment management and test data management

No major step-changes – but steady growth continues

ROBERT MALLAFRE
TDM Practice Lead, Digital Assurance & Testing, Sogeti, Spain

ANISH BEHANAN
Senior Director & Practice Leader,
Digital Assurance & Quality Engineering

JEBA ABRAHAM
Regional DAQE Practice Leader, Sogeti, North America

> *Test data management presents difficulties, too. The choice is between field data, which can't always be updated too easily, and synthetic data, which can be difficult to generate in a way that's meaningful over many iterations, and at scale. Right now, we're looking at various tools for test data provisioning – and our own test orchestration platform is helping, too.*

ANAND DEVANATHAN
Director, Digital Assurance & QE, VMware

In a sense, each World Quality Report provides answers not just to the questions in our annual survey, but also to the questions we set ourselves more generally in previous editions. For instance, if we detected certain trends, and sensed certain moods, regarding test environment management (TEM) and test data management (TDM) in 2020, to what extent have they been corroborated in the year since then?

Let's look at a few of them in turn. First, as a general point, in 2020 we said TEM and TDM were making slow but steady progress. And this year? Well, yes, this still seems to be the case. There has been a gradual shift of environments into the cloud, and this has introduced new challenges, such as ensuring that cloud-based apps remain in sync with legacy apps. Overall, however, we have observed the same general direction and pace of travel in the field, and as we'll see shortly, it's in evidence in the survey data, too.

Incidentally, the growing demand we've seen over the last year for cloud-based environments has been fueled partly by the push for digital transformation, and partly by the increase in remote work. In some instances in the field, we've seen related costs rise disproportionately, which companies are now trying to rationalize.

On a more specific point last year, we noted organizations still needed to figure out how to spin up test data and test environments on demand – and this year, we're pleased to say that overall, this ability has indeed grown.

Last year's survey was conducted in the midst of the first wave of the global pandemic, and so we naturally wondered whether COVID would accelerate change. From the evidence of our own experiences, the short answer seems to be yes. We've seen increases in data masking and rationalization initiatives; we've seen growth in security initiatives, probably because of the numbers of people working remotely; and we've also seen test environments flex to reflect the new normal: for example, people want to look at data in different ways now.
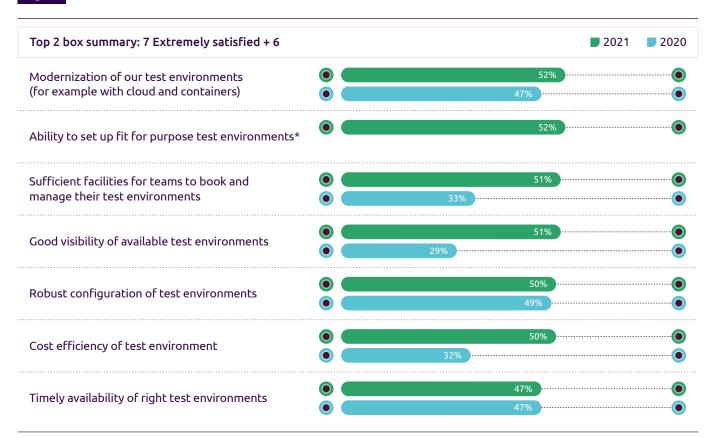
Test environment types…

This, then, is our own preliminary take on the extent to which last year's forecasts have taken shape in TEM and TDM. What, though, of the evidence provided by the responses to this year's survey questions?

For several years now, we've been asking people about the percentage of their testing that occurs in each type of testing environment. It's therefore straightforward to identify trends – and what we see this year is that the direction of travel is pretty consistent. Our opening remarks about the growth of cloud-based test environments are corroborated here: there has been a steady growth in this area over the last four years, to the point where respondents are now telling us that 23% of their testing occurs in this space.

There has also been a corresponding drop year on year in the proportion of testing occurring in traditional test environments. The percentage of all testing in this case has now reduced to 24%. In addition, and as we'd expect, we're seeing modest increases in the use of virtualized test environments; in on-demand temporary test environments; and in containerized test environments, such as Docker.

All of which prompts us to wonder why these developments are all so gradual. Why has there been no tipping point, no major step change? It could partly be because in the move towards DevOps, there is a lot more focus on continuous deployment aspects than on continuous integration, where a lot of the environment virtualization or infrastructure-as-code skills and capabilities reside It could also partly be because moving to the cloud is a big investment decision, and the transition would be happening faster if it weren't for what we might term "cost hesitancy."

Fig 10   QA team's ability to succeed in achieving the targets related to test environments

Top 2 box summary: 7 Extremely satisfied + 6   ■ 2021 ■ 2020

	2021	2020
Modernization of our test environments (for example with cloud and containers)	52%	47%
Ability to set up fit for purpose test environments*	52%	
Sufficient facilities for teams to book and manage their test environments	51%	33%
Good visibility of available test environments	51%	29%
Robust configuration of test environments	50%	49%
Cost efficiency of test environment	50%	32%
Timely availability of right test environments	47%	47%

New option introduced in 2021 study

… and test environment confidence

What do organizations make of their progress against various targets in test environments (see Fig 10)?

In general, as you can see, there is a greater sense of satisfaction this year, and in many instances, the increase since last year is considerable. This makes sense to us; developments in technology over the last five years have been substantial, and as we noted earlier, it's much easier now to spin up new environments.

Satisfaction with cost efficiency is one of the big risers, which is heartening to note. In our experience, cost efficiency depends to a large degree on how effectively test environments are used; some organizations generate far more of them than they need.

Easily the biggest increase here is in the number of respondents who said they were highly satisfied with the visibility of their available test environments (51%). This is of course a major management benefit.

> *In the SAP world, test data is critical. It's a key driver for test automation, and for test quality in general. Right now, we're automating scripts in two steps: pre-validation, and then the actual test. We need better test data tools.*

JOSÉ JIMÉNEZ
SAP test management lead JTI

Test data practices

We also see significant movement in the frequency with which organizations are applying various test data practices (see Fig 11).

More than half of our respondents said they were employing these test data practices in every case, and many of them have risen significantly. For example, the number of respondents saying their teams always comply with data security and data privacy regulations for their test data has risen ten percentage points, to 55%. There is also substantial growth in the number of people saying their teams use the appropriate test data management tools (55% once more).

Fig 11   Frequency of application of the following test data practices

Top 2 box summary: 7 Always use this practice + 6   ■ 2021 ■ 2020

Practice	2021	2020
Our teams create small sets of test data dedicated for each sprint*	55%	
Our teams use a dedicated test data support team to provide test data as a service*	55%	
Our teams use appropriate test data management tools	55%	47%
Our teams comply with data security and data privacy regulations for test data	55%	45%
Our teams have generated a bulk data set and re-use it for every sprint*	55%	
Our teams work with copies from production for testing	54%	46%
Our teams are aware of and have access to clear processes to obtain test data*	53%	
Our teams have sufficient test data for all our testing	53%	45%
Our teams create and maintain synthetic test data for testing	52%	58%
Our teams are able to manage the size and complexity of test data sets	51%	61%

At first sight, there is a seeming contradiction between the high number saying their teams always create small sets of test data dedicated to each sprint (56%) and the number saying their teams generate a bulk data set and reuse it for every sprint (55%). In fact, it's probably and simply because organizations are using different approaches in different circumstances.

Given the general upward tick we see in this graph, the drops in the last two bars might seem incongruous. In our view, they can be explained by the fact that all the previous options involved pretty binary decisions in the heads of people answering the question – for example, "Yes, we do/no we don't have a dedicated test data support team." But the bottom line on the graph is less of a clear-cut choice. "Can our teams manage the size and complexity of their test data sets? We need to think about our entire test data structure here, and there are variables." In weighing up these variables, fewer people may have decided they could be confident here.

We feel the use of synthetic data is dropping because teams are more likely to be copying production data into development and test cycles, simply because it's easier: it can be hard to synthesize something of this complexity.

Summary

Taking stock, then. As with last year, so again this year, we see steady progress in the development of test environments and test data. Environments are continuing to move to the cloud, and organizations are finding it ever easier to spin up test data and test environments on demand. People are happy with the progress they're making, both with test environments, and with test data.

Is there any cause for excitement here? No. But there's plenty of good reasons to be optimistic about progress, and that's plenty good enough. Excitement can be so overrated.

" *As a long-established enterprise, we have some legacy architecture – so we build test environment models to see how things might react. We call it 'limiting the blast radius.' While some people focus on their existing as-is architectures, and on getting those into their continuous testing cycles, we build models around how the interfaces should work, and not how they currently do – especially if they're not fit for purpose.*"

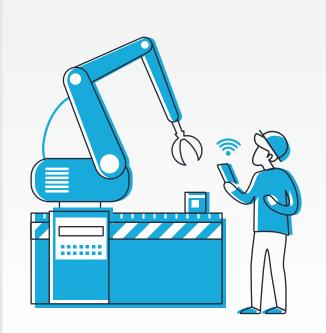**RICHARD JORDAN**

Test Engineering Manager, Nationwide

" *We've invested in test development and test generation tools, so we can build data sets and unit tests against various criteria – for instance, a policy that insures a family of three drivers with four cars. There's an element of time travel to testing in the insurance industry. For example, we'll run routines side by side in legacy and newly developed environments, and play unit tests one against the other, to see what works best.*"

JERRY BOGLE

Technology Director,
Enterprise Technology – StateFarm Insurance

Intelligent industry

New territory – and cautious confidence

ATUL JADHAV
Director, Quality Engineering & Automation Capgemini Engineering

MANISH GOYAL
Portfolio Manager, DAQE, Capgemini, India

PEDRO COSTA
Head of Offer & Portfolio at Capgemini Engineering Portugal

> " *All these technologies are spreading intelligence out from the center. The basic testing principles aren't changing as a result – there's the same need for quality at speed – but they are deepening. Out at the edge, in some instances there's going to be a need for greater security, and more resilience. It will probably mean higher levels of assurance are needed – up to a five-9s level, perhaps.* "

ANAND DEVANATHAN
Director, Digital Assurance & QE, VMware

This year, the World Quality Report is dedicating a section to quality engineering in Intelligent Industry. It's the first time we've done so, but it won't be the last. The momentum for digital transformation is building, and we're seeing ever more companies focusing on how to digitize the key industrial parts of their business. They're looking at how they use embedded software, data, 5G, edge computing, artificial intelligence (AI), automation, and the internet of things (IoT) to rethink what they do, and how they do it.

It's new territory for many, and as we shall see when we come to consider the survey data, this has a bearing on the extent to which quality issues are a factor. In some areas, it's a given. For instance, one of the basic principles of intelligent industry is that it extends technology out from the center, embedding it in devices near and far – and this, in turn, increases cybersecurity and data privacy pressures, where quality is paramount.

In other areas, the role of QE in intelligent industry is less clear-cut. Take the financial services sector, for example. On the face of it, these technologies are less applicable in such areas than in, say, automobile manufacturing. But wait – these things are interrelated. Cars are now sufficiently smart and connected to be their own point of sale, which means they can enable drivers buying or hiring them to book full or temporary insurance from the dashboard. They can also provide feedback of road traffic accidents or breakdowns in real time. All such functionality has implications for the financial services sector, so we can see that yes, Intelligent Industry arguments apply here, too.

The key takeaway here is that this is an area in which we can expect new value-added service opportunities, and hence new software requirements, in all kinds of sectors – some of which no one is yet able to see. All of which makes quality issues simultaneously important and hard to gauge.

First principles

Before assessing attitudes to quality assurance in this area in any detail, we felt it would be useful to gain a sense of people's primary motivations for organizational change, and for areas of focus for making that change. We therefore asked our survey respondents to rank the key drivers for intelligent industry as the next stage in their digital transformation (see Fig 12).
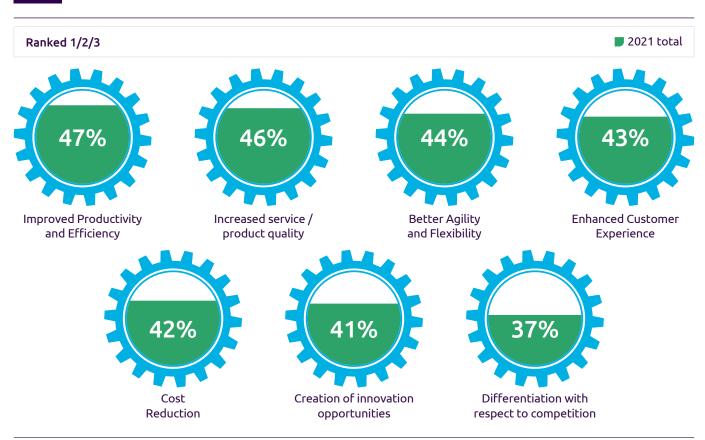
It is interesting to note that the spread here is not very wide. Between the highest-ranked and sixth-ranked options, the difference is only six percentage points. This may be because at this early stage of transition, for many organizations everything seems to be of equal importance, with the greatest weight given to those qualities for which digital transformation is well known – in other words, to efficiency, quality, flexibility, and improved customer experience.

That said, though, we do find it a little surprising that cost reduction does not come higher, which implies that organizations are perhaps ready to invest more in terms of resources, skills, tools, and more. It's even more surprising to see competitive differentiation not only come last, but several points behind the other options. In several industries, including financial services, health, and automotive, we have noted a great deal of post-COVID pressure to compete. The pandemic has disrupted markets, and disruption creates opportunities that established players and newcomers alike are keen to exploit.

Over the course of the next year, organizations will be making further headway in their intelligent industry efforts. We expect that in next year's report, the experience they have accrued will be reflected in greater weight being given to competitive edge, and also in a less balanced picture overall. We'll be watching this one with interest.

Fig 12 Importance of the key drivers for next stage of digital transformation in organizations

Ranked 1/2/3   ■ 2021 total

47%
Improved Productivity and Efficiency

46%
Increased service / product quality

44%
Better Agility and Flexibility

43%
Enhanced Customer Experience

42%
Cost Reduction

41%
Creation of innovation opportunities

37%
Differentiation with respect to competition

Key development factors

This, then, was the all-bases-covered response to a business-wide assessment of intelligent industry. But we're here principally to consider quality issues – so what did people think would make the biggest impact on Intelligent Industry initiatives from this perspective?

The highest rating was given to team skills, with 55% of respondents ranking this among the top three. In this emerging area, this is no surprise. Test tools also ranked high, at 53%. This, perhaps, is because organizations are still getting to grips with the smart tools that go with this territory. As we saw just now, organizations are perhaps ready to invest more in areas that will help improve productivity, efficiency, quality, and flexibility in a shorter timeframe.

Test infrastructure was rated highly by 51% of respondents. In our view, this could have been even higher, driven by the extent to which as-a-Service testing approaches are becoming mainstream.

The lowest option chosen was QE organization, which was rated highly by 44% of respondents. We suspect this is simply because many of them feel the team structures they will need are in place already.

Organizational readiness, skills, and V&V focus areas

How important do people think it is for organizations to be ready to address V&V (verification and validation) of intelligent industry domains and technologies? It's in an interesting question,

"People instinctively understand the process of online shopping, for example. But banking is a different proposition. It's more sensitive, it's more private, and so there needs to be more of an educational element to taking transactions online. The software we develop and test needs to reflect this."

BRANDY FITZPATRICK
Vice President , Quality Management Office,
Fifth Third Bank

because it asks not whether organizations are indeed ready, but where they think the focus should be.

The responses (see Fig 13) are equally interesting. At 61% of respondents, equal-highest responses are leadership support and funding, and development of proof of concept/pilot. These are the priorities of organizations taking their first steps on a path – it's all about getting buy-in and demonstrating feasibility. What we might term later-stage priorities, such as establishing an innovation ecosystem or a simulation environment, come lower down the list.

At first glance, it may seem a little surprising that skills and test infrastructure, which ranked fairly high in the previous question, should feature less heavily here. However, it's worth noting that the earlier responses related to general principles, whereas here, we're looking more specifically at an organization's readiness.

Fig 13   Organization readiness to address testing of Intelligent Industry domains and technologies

Top 2 box summary: 7 Essential + 6   ■ 2021 total

Leadership support and funding	Development of Proof of Concept/Pilot	Test Tools, Frameworks (Buy/Build)	Resource Upskilling/ training	Technology competency	Innovation ecosystem	Test Infrastructure/ Bench, Simulation environment
61%	61%	60%	59%	57%	57%	56%

Skills issues always feature heavily in the World Quality Report, so in this new subject area, we felt it would be worth drilling down. Which skills are most relevant to QE teams in Intelligent Industry?

The leading options were cloud computing, ranked among the top three by 42% of respondents; cyber-security (41%); and big data and analytics (40%). So, no surprises here, really; in an increasingly smart digital environment, we can see where people are focusing right now.

It's also useful to consider which areas are deemed to be the most important for autonomous/ADAS/smart products/smart factory V&V. Artificial intelligence and machine learning continue to play a key role across industries and offer a key advantage as part of quality assurance. As we might expect, regulatory compliance and cybersecurity featured prominently, with 68% and 67% of respondents respectively giving them high ratings. However, perhaps more interesting is the fact that the next two highest responses were simulation-driven validation (66%) and scenario-based testing (64%) – a sign that virtual V&V is playing an increasingly important role.

Looking ahead

Given that intelligent industry marks a significant shift for many organizations, there is clearly a need for them to look to the future. What do they think their testing infrastructure and teams will be like?

A sizeable 42% of survey respondents felt they would be upgrading their existing test labs with capabilities in 5G, IoT, AI, and autonomous systems. It's a sign of confidence, we feel, that they can accommodate these new technologies. If they're not ready right now, they clearly feel they will be. It may be the case that they haven't yet fully realized the scope of investment that will be necessary – in which case, it will be interesting to see if experience makes a difference in responses to this question next year.

A significant proportion of respondents – 10% – said that testing products with emerging technologies was not a priority for them right now. It may be that developments are at too early a stage for some of these organizations, and for others, it may be COVID-related: in the light of the pandemic, many companies have had to focus first and foremost on short-term cost control. Another reason could be that most organizations following a "fail-fast" approach would not want to invest heavily in the early phases, but would rather wait for sufficient results to prove the product's or solution's efficacy.

It's not just in terms of the evolution of team strategy that organizations are feeling their way. As we noted at the outset of this section, intelligent industry is new territory for many. Here, and also in the other questions we've considered, there are signs that people are still feeling their way. With greater insight, and possibly with greater confidence, we can expect to see a greater polarization of opinion next year.

We've been active in test automation for many years. I lead the team. One of the challenges is that senior people focus on automation to the exclusion of everything else, but it's not a one-size-fits-all technique. To make test automation effective, what you're doing needs to be repeatable, and predictable. That's why we build models first – what you might call digital twins. They give us a clearer, more predictable basis on which to build and plan automation programs.

The crux with AI in testing is to get people to think about the business application. They're too focused on the glamor of the technology. That's why we keep dragging them back to our digital twin approach, which is all about real-world applicability.

RICHARD JORDAN
Test Engineering Manager, Nationwide

SECTOR ANALYSIS

Automotive

Enthusiasm for the road ahead

AXEL SCHOENWALD
Head of Sector, Automotive, Sogeti

The impact of the pandemic on the travel and hospitality sector is well known, but its effects on the automotive industry have also been considerable. Last year's World Quality Report was written a few months into lockdown, and we noted then that what had been a growing trend to think of cars as a service, rather than as an owned product, had been disrupted. Concerns about transmissibility and social distancing put ownership back on the agenda, and in the year that has passed since, we've seen that trend continue. For example, in some geographical markets, sales are increasing among young women; virus awareness is outweighing green awareness.

Does this mean that cars are once more seen only in terms of their ability to move us individually from A to B? Not at all. As we also observed last year, automotive manufacturers are morphing into mobility services providers, and the services element is as important as the mobility. It's a point that's illustrated by Volkswagen's launch earlier this year of CARIAD (Car, I Am Digital), its new brand for digital transformation. Just as major smartphone manufacturers allow third-party developers to create approved apps, so CARIAD provides a unified technology and software environment, including a vehicle OS, vehicle cloud platform, and a new unified architecture for all of Volkswagen

Group's brands, of which third-party developers can be part. Similarly, Daimler has announced that the Mercedes OS will go on the market in 2024.

What does all this convey? It tells us that software development and testing are more important than ever in this industry, and that their significance can only grow.

Moving up – and shifting left

Our survey data provides a picture of progress, and this year is no exception. When asked to assess the importance of different aspects of their overall IT strategy, the highest-rated option for automotive industry respondents (65%) was for the higher quality of software solutions, with higher responsiveness to business demands not far behind (61%).

Feedback on the importance of objectives specifically in testing and quality assurance (QA) is consistent with the results we saw in last year's survey. Ensuring end-user satisfaction and a good customer experience (CX) was rated highly by two-thirds of the sector's respondents (67%), and in a later question, CX

validation and usability testing received a high rating by most respondents (51%) as a factor on which focus is needed in the post-COVID world.

Almost as many (65%) put emphasis on making QA and testing a smarter, more automated process. We see these CX and automation trends in the field. In particular, we see automation performing a role at different stages in the test cycle, as part of a shift towards end-to-end testing.

A similarly high proportion of respondents (64%) felt that the tools and methods required for their test activities are sufficient and available. Our experience in the industry leads us to suspect that in many of these cases, engineers are acquiring and experimenting with new QA tools out of curiosity, and that this doesn't necessarily equate to customer outcomes. The survey data seems to corroborate this: fewer than half (48%) of the industry's respondents said application development requirements were clearly defined, which was several points below the survey average. Indeed, we are aware of some organizations that are calling their teams to order and reinforcing what's good for customers over what is merely possible or interesting.

The industry's interest in software tools is also evident in a question about budget splits. Last year, respondents told us that 45% of their budget was used for hardware and infrastructure, and 32% on tools, with the remainder going to human resources. This year, the hardware figure dropped to 40%, and the tools figure rose to 36%, with HR budget allocation moving just one point.

Last year, we also observed that this was an industry that saw the value in shifting left – and this year, we see that once again. Among the critical success factors in making testing more efficient, shift left testing was deemed vital by 61% of respondents. This option was one of the highest rated by the sector, and it was also significantly above the average across survey respondents as a whole.

Progress in agile and DevOps environments

Developments in agile and DevOps are continuing to evolve in the automotive sector. In an agile context, the most common challenge cited was the difficulty of automating test activities, which was ranked high by almost half (47%) of the sector's respondents. On a more positive note, we see more than half of them (52%) saying that in order to accelerate and optimize their testing in these environments, they are preparing and executing their tests as early as possible – in other words, shifting left.

How are agile and DevOps working out for them? Pretty well, it seems: in terms of quality of software, productivity, cost of quality, and speed to market, roughly two-thirds of automotive

respondents said they are achieving excellent or very good improvements. Among these categories, the quality of software attracted the lowest number of high scores, at 61%, which was below the survey-wide average of 69%. One reason for this may be that, in response to another question, fewer than a third (31%) of respondents said they always or almost always track defect leakage into production. For an industry with a shift left mindset, this figure ought to be higher. Overall, it seems there is still a need for agile teams to invest in this area.

Enthusiasm for test automation

As we just saw, many organizations in the automotive sector find test automation a challenge – but that doesn't mean it's something they avoid. In manufacturing production, it's something that has been in their DNA for decades, and now they're bringing it into their software QA processes, too. In a question that gauges confidence in this area, many of the sector's responses leave the survey averages far behind. Around two-thirds (65%) of them said their applications have achieved the desired level of stability for test automation, and also that they have implemented AI/ML-enabled test automation solutions. They feel they have the automation tools (60%); that they have the right automation strategy (55%); and that they get ROI from their automation efforts (also 55%).

Those returns on investment can be seen in the benefits that organizations say they are realizing. Automotive respondents reported higher-than-average improvements in control and transparency of their test activities, in reduction of their test cycle times, in shift left defect detection, and in test cost reduction.

Test environment confidence

Automotive respondents said that around a quarter (24%) of their testing occurs in cloud-based permanent test environments, and that 19% occurs using virtualized interfaces in test environments. We expect these proportions to rise in years to come, as a big data approach normalizes, and also as virtualization increases, not just with respect to the software, but with respect to the hardware, too.

Confidence in achieving test environment targets is markedly different. For example, last year, 28% said they have sufficient facilities for teams to book and manage their test environments. This year, that figure stands at a hugely improved 57%. Last year, a quarter (25%) of respondents were highly satisfied with the cost efficiency of their test environments. This year, the figure rose to 48%. This has to be good news.

Tailor-made for the intelligent industry concept

The automotive sector is an area for which the concept of intelligent industry is highly apposite. Digital transformation, which embraces 5G, the internet of things (IoT), automation, artificial intelligence, and more, is tailor-made for a market that manages to be manufacturing-based and consumer-driven at the same time.

This is why in this year's figures we see so much attention being given to the key imperatives of digital transformation. The sector's respondents gave higher-than-average weightings to improved productivity and efficiency; to cost reduction; to the creation of opportunities for innovation; and to competitive differentiation. We expect these outcomes to manifest themselves in different ways in the twin streams of the in-car experience and of factory operations.

Looking down the road

This is a market in which just about every major development – driverless cars, on-board diagnostics, electrification, and more – brings with it a need for more and better technology, and hence for smarter and more comprehensive software development and testing.

The trends we saw last year are the same as those we see this year, and there's no reason to think they will be any different in future. The only major variable is likely to be the pace at which things change.

Consumer products, retail and distribution
Strategic thinking, and an accelerated pace of change

Ajith Madhavan
Vice President, Capgemini USA

You don't need to be a business analyst to know that when COVID-19 took hold in 2020, the retail world turned upside down. Lockdown changed things; bricks-and-mortar shopping either slowed to a trickle or ended completely, and retailers and manufacturers of consumer products were obliged to ramp up their online presence to increase their supply-side flexibility and to find new channels to their customers.

These were precisely the observations we made this time last year, and since then, the IT ramifications have, if anything, increased. Organizations in consumer products, retail, and distribution (CPRD) have raised their game, producing more apps, handling transactions in greater volumes, and addressing greater pressures in functionality in general, and in customer experience (CX) in particular.

These were all largely tactical reactions, forced on organizations by circumstance. But as we now enter a post-pandemic phase, they are starting to think more strategically. In the field now, we see efforts to consolidate the new business model that has emerged, integrating planning and functions from end to end – from materials sourcing, to production, to marketing, to fulfilment, and beyond. It's a new world, meeting new customer expectations, and quality assurance (QA) is more pivotal than ever.

A clear direction of travel

What effects have this new world had on our CPRD survey data this year? In many respects, there is a change only in momentum, but not in direction of travel. It was no surprise, for instance, to see the sector's respondents telling us one of the most important aspects of their IT strategy is to enhance the customer experience (rated as vital by 69% of them). In these markets, CX is pretty broad territory. It can mean the online purchase of a designer item, in which enhancing the experience might involve building the brand's values into the transaction journey. Or, if it's a straightforward commodity purchase, such as buying a new ream of printer paper, it can mean simply increased convenience – making the process as hassle-free as possible. Implicit in this is making the software that underpins the process frictionless, by integrating and simplifying its architectures. This can be no small undertaking. It means that enhancing the CX for something as simple as buying printer paper can have significant implications for software development and test.

There seems to be a little confusion about the extent to which CPRD organizations are achieving their targets for applications development. On one hand, higher-than-average numbers of them said their requirements are clearly defined (57%), and that

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their testing is optimized in terms of speed and cost (56%) – but a mystifyingly lower-than-average 56% felt their testing is complete, and only half of them (50%) said enough time was available for testing.

Overall, however, the direction of travel is indeed clear. There were marked differences between where CPRD respondents are focusing their quality efforts now, and where they anticipate the focus will be two years from now. Chief among them was an anticipated rise in acceptance testing, cited by 44% now, but by 70% looking ahead to 2023. It's a further illustration of the importance of enhancing CX.

Prevailing trends are also evident in people's views of key factors in efficiency. The CPRD sector posted higher-than-average weightings for shift-left testing (58% of respondents), enhanced test environment provisioning (50%), and increased levels of test automation (49%).

The world's gradual emergence from COVID-19 has also prompted people to take stock of their priorities, and in a question about this, we see once again an emphasis on the importance of CX validation and usability testing (rated highly by 46% of CPRD respondents), and on improved automation of QA activities (48%). Other factors attracting attention included first, disaster recovery and resilience testing, and second, the security validation of applications, both of which were rated highly by 40% of respondents.

Challenges, but progress too

In agile development, it was interesting to note that the greatest perceived testing challenge was a difficulty in getting the right test environments and test data. This was weighted heavily by 53% of CPRD respondents, against a survey-wide average of just 41%. We see this in evidence again in later questions. In one case, only a third (33%) of CPRD respondents said their test data and test environments were available at the right time, against a global average of around a half (49%). Elsewhere, only 43% of respondents said their teams have sufficient test data for all their testing. Greater effort is clearly needed here; the availability of good test data is crucial in this sector. It probably explains why only 44% of respondents said they always or almost always get a return on investment on their test automation efforts.

In another case, respondents were asked to gauge their teams' ability to succeed in relation to various test environment targets – and in every instance, CPRD responses were below average. These included the ability to set up test environments that were fit for purpose; the cost efficiency of environments; and the timely availability of environments. This, too, should be an area of focus for improvement.

In general, however, the sector's teams feel they are doing well. In another question, they reported excellent or very good improvements have been achieved as a result of using agile or DevOps, with higher-than-average figures in every category: quality of software (76% of respondents, against a survey average of 69%), productivity (75%, versus a survey average of 69%), cost of quality (68%, a point higher than the survey average), and speed to market (69%, versus a survey-wide average of 64%). There is clear confidence here, and we see it in evidence in the field, too.

The sector's outcome-driven mindset is in evidence in responses to a question about critical success factors for agile and DevOps adoption. Business priorities were rated as vital by more than half of respondents (53%), and the culture and agility of the organization ranked almost as high (49%). The factor given a high rating by the fewest respondents was executive support (45%). This doesn't surprise us: in our view, the adoption of agile or DevOps is a tactical decision, rather than a strategic one requiring board-level input.

There is room for some optimism in test automation. For example, a sizeable 61% of CPRD respondents felt they are achieving better control and transparency of their test activities, and in addition, organizations estimated that their use of test automation was delivering reductions of 28% in their overall security risk and security-related issues in code. However, it was disheartening to see a significantly lower-than-average 43% of respondents saying that self-healing using artificial intelligence (AI) and machine learning (ML) was an automation technique they would be using during the coming year. In this sector, AI still constitutes a weakness in QA, and adoption levels are low.

CPRD and the Intelligent Industry

At the outset of this article, we noted that the global pandemic had accelerated digital transformation in the CPRD sector, and for the first time this year, our survey asked people to consider QA in that context. It's what we've called the intelligent industry, in which organizations digitize the key industrial parts of their businesses. They're using embedded software, data, 5G, edge computing, smart technologies, automation, and the internet of things (IoT) to rethink what they do, and how they do it.

One of the most influential drivers for CPRD organizations in this respect is improved productivity and efficiency, which was ranked highly by 44% of the sector's respondents. In our view, though, it's more circular than this. Enhanced productivity and efficiency aren't just an ambition that digital transformation makes possible – they are also necessary for its achievement. When operational siloes are removed, and when systems are integrated, that's when performance can be optimized, and when organizations can introduce Intelligent Industry principles and take full advantage of them.

What skills in QA teams are most relevant to the intelligent industry? The options ranked highest in this sector were big data and analytics (ranked highly by 47% of respondents), and AI and machine learning (45%). Other options, such as cloud computing, cybersecurity, advanced simulation, and robotics and automation, all attracted lower numbers of high rankings – but in our view, they are all of equal importance.

Busy times ahead

We see no reason for the direction of travel to change for CPRD businesses as far as QA is concerned. There will be more test automation, and also, it's likely that customer pressures will result in growth of subscription-based models. The major online platform retailers remain front of mind by constantly reinventing their offer, and their competitors will need to do the same. Which means more software releases. Which in turn means greater pressure on QA teams, and even more test automation, and greater use of AI and machine learning.

For CPRD, these are going to be busy times. When was it ever otherwise?

Energy, utilities, and chemicals

The drive to transform

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In last year's World Quality Report, we noted that the energy, utilities, and chemicals (EUC) industries had been dealt a particularly severe blow by the early stages of the pandemic. The year that has passed since then has also been difficult: problems of oversupply and of security have been joined by growing regulatory concerns, especially with respect to the environment.

As a result, EUC organizations have needed to accelerate their attempts to move away from fossil fuels – and this, in turn, has increased cost pressures, in order to free up budget for digital transformation and for the move to renewables. At the time of writing, it's fair to say these industries are still in recovery mode.

Highly regulated and risk-averse

It's against this background that we must assess the views of our respondents on the importance of various aspects of their IT strategy. These are largely business-to-business markets, so we would expect the high ratings given to security and to responsiveness to business demands. In fact, we might have expected the need to enhance security to be ranked even higher than it was. For the same reason, we would also expect the far lower-than-average number of EUC respondents to highlight the importance of enhancing the customer experience.

A greater-than-average 56% of them emphasized the need to achieve a faster time to market. These organizations are in highly regulated industries, and many of them are very large – indeed, 55% of our EUC cohort are from enterprises employing more than 10,000 people – and so developments tend to take a while to achieve. It's no surprise, therefore, that time to market was so top of mind.

For testing and quality assurance (QA) in particular, the most important objective was adjudged by EUC respondents to be supporting everybody in the team to achieve higher quality. In the case of other industries, we have sometimes taken this as an indicator of agile adoption, but we don't feel that is the case here: in our experience, not many organizations in EUC sectors have yet made much progress in agile. The collective responsibility for quality is more likely to be because these are highly risk-averse markets.

Tools issues

EUC respondents had mixed feelings about the extent to which they are achieving their application development targets. While a high proportion of them (61%) said that activities across distributed teams are always or almost always well-orchestrated and integrated, far fewer (46%) felt able to say that the tools and methods they need for their test activities are sufficient and available. This may be because of the huge scale of operations for many organizations in these sectors. As we shall see, this is a recurring theme. Similarly, a lower-than-average 50% of EUC respondents said they always or almost always have sufficient test environments when they need them.

Key efficiency factors were largely in line with expectations. High-scoring options included the availability of adequate staff with the right skills; better communication and collaboration across the lifecycle; and better test data generation and provisioning solutions. While aspects of test data are earmarked here as aspects of efficiency, that doesn't mean EUC organizations have no issues in this respect. Elsewhere in the survey, we see lower-than-average numbers of EUC respondents saying that they comply with data security and data privacy regulations for their test data, that they have sufficient test data, that their teams create and maintain synthetic data for testing, and that they always use appropriate test data management tools. These are issues we also see in the field – and once again, the problem of tools availability is articulated.

The tools issue arises yet again as an area of focus in the post-COVID world. Almost half (48%) of EUC respondents – which is significantly highly than the survey average – gave a high ranking to the need for better collaboration tools for their teams.

Test environments: a slower shift to the cloud

For other sectors covered in this report, we've observed that, for test environments, the balance will shift in the next year or two away from traditional on-premises configurations, and towards cloud-based permanent test environments, and also towards virtualized test environment interfaces.

We expect that same shift to occur in the energy, utilities, and chemicals sectors, but probably not to the same degree, or at the same pace. This is because, as we've already noted, these are highly regulated industries. Nuclear energy organizations, for instance, are subject to tighter cloud controls than most. In addition, implicit in a transition to the cloud is a shift from capex to opex – and here, too, regulatory approvals will be needed.

Agile and DevOps: a road still to travel

We observed earlier that many EUC organizations still have some distance to travel in agile and DevOps adoption, and detailed survey data on this topic seems to bear this out. Notable challenges in this area included difficulty in automating test activities, and also, as you may have guessed by now, a difficulty in aligning which tools should be used in agile teams.

There has been a substantial drop in the numbers of EUC respondents saying they shift left, with 40% of them saying they always do this, against 55% last year. We suspect this may be because of the significant challenges that organizations are facing right now. As they emerge from the pandemic, they are simultaneously dealing with its fallout, and shifting their operational center of gravity towards renewables. In this context, shifting test up to earlier in the software development lifecycle is a big additional ask.

It's no surprise to see where the greatest perceived skills gaps are this year. Substantially higher-than-average numbers of EUC respondents cited knowledge of test automation skills (41%) and build and deployment tool knowledge (35%) – yet more difficulty with tools. These are clearly areas in which investment needs to be made.

In spite of all this, there are some promising signs. High numbers of respondents in these sectors reported improvements as a result of their adoption of agile and DevOps. Against a survey-wide average of 69%, over three-quarters of them said they achieved excellent or very good improvements in productivity (78%) and in quality of software (76%). A lower-than-average 57% claimed substantial improvements in speed to market, but it's important to remember that these are capital-intensive industries, and it can take some time for investments to pay dividends.

Challenges in test automation, AI, and ML

Intelligent test automation seems to be improving test processes to a greater degree than test outcomes. For example, easily the greatest automation benefit for EUC organizations is better control and transparency of test activities, as reported by 69% of the sectors' respondents, whereas the early detection of defects as a result of automation was claimed by only 43%. There is clearly enthusiasm for the approach and for the advantages it can deliver, but it's notable that, on balance, fewer EUC organizations than average said they would be employing various automation techniques in the coming year. The skills gap in this area that we noted earlier will need to be addressed before organizations can scale up in its use.

Last year, we observed some advances in the use of artificial intelligence (AI) and machine learning (ML) in testing and quality assurance, but this year, progress seems to have stalled. Survey results suggest this is partly because of a lack of trust: only a quarter (27%) of EUC respondents agreed their business owners trust the intelligence provided by their AI/ML platform (against a survey average of 42%), and the same 27% agreed that application owners share that trust, against a survey average of 41%.

It's not just about trust, though. It's also about talent. In our experience, energy and utilities businesses are finding it difficult to retain staff with smart skills. People are being drawn away into other sectors. Responses to a question specifically about AI skills bear this out: perceived skills gaps in disciplines such as test strategy and test design, data science, and the understanding of bias associated with the use of AI/ML were significantly higher than average.

Enthusiasm for intelligent industry

In a new survey section this year, we've asked respondents about Intelligent Industry, which is about organizations digitizing the key industrial parts of their businesses, and in particular, about using embedded software, data, 5G, edge computing, smart technologies, automation, and the internet of things (IoT).

The intelligent industry concept is particularly appropriate to EUC organizations. It represents a big and growing opportunity, because these are industries with widely dispersed equipment in the field, for which remote monitoring is a distinct benefit.

There are two additional factors. First, as organizations transition to renewables, the demands on remote monitoring will extend, because more and different types of data will need to be captured and actioned; and second, the pandemic has resulted in layoffs in the oil and gas sector, and it's likely that automated monitoring will be used to plug the gap as operations resume. These layoffs probably explain why the need for organization, strategy and tools in this area was adjudged by EUC respondents to be so much more important than team skills.

Given the importance of intelligent industry developments to energy, utilities, and chemicals businesses, it's perhaps no surprise to see the plans they are putting in place for their testing infrastructure in this area. A lower-than-average number of them said they will be upgrading their existing test labs with capabilities in 5G, IoT, and AI, but a much higher-than-average number said they would be creating a new, fit-for-purpose test lab. In fact, more than a quarter (27%) of them said this, which is higher than anything we've seen elsewhere in this year's survey. This is clearly an area in which EUC businesses plan to invest.

Taking stock

The picture that emerges from this analysis is of a group of industries that is still scaling and maturing, in its use of AI, of intelligent test automation, of tools, and of QA and testing in general. These are markets that were hard hit last year, and the regulatory environment in which they operate hampers the pace at which they can innovate and invest.

That said, though, they can't afford to wait. The global pressure to transition to new forms of energy means the IT dynamic will need to change, and that includes the key area of quality assurance and testing. Businesses in these markets will need to revise their budgets, double down on their determination, and go for it.

Financial services

Full steam ahead

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Much is at stake in the world of financial services, so the fact that this sector is a technology trailblazer is no surprise. Even in normal circumstances, the banking, capital markets, and insurance markets are among the first to explore and adopt new technologies that either boost performance, save time, make new services possible, or do all the above simultaneously. This early adopter positioning has obvious implications for quality assurance (QA), and in last year's report, we saw much progress in key areas.

Of course, the year that has passed since then has been anything but normal. As we shall see, in many instances, the net effect has been to accelerate rather than hinder the pace of change.

Growing confidence

Our financial services sector respondents were asked to rate the importance of various aspects of their general IT strategy, and it was no surprise to find that the top three included enhancing security (rated highly by 65% of respondents), and a higher responsiveness to business demands (63%). These values were higher than those seen in any other sector in this year's report. However, the highest rating (69%) was given to enhancing customer experience. This, too, was as expected; the lifestyle changes wrought by the global pandemic have made a significant impact on user expectations. We were a little

surprised, though, that the cost optimization of IT was rated highly by only 56% of the sector's respondents. Perhaps it's because many organizations, especially those in banking, feel they already have this well in hand.

Specifically in testing and quality assurance, the highest-rated objective was quality enablement (69% of respondents). Quality enablement involves supporting everyone in the team to achieve higher quality, and as we also saw last year, this shared sense of responsibility is very much a factor in financial services QA. What were once individual roles are now blurring. In banking, for example, we are seeing people moving into senior roles who come from non-traditional backgrounds, such as the popular electronic payment platforms. It means they have a product mindset, and that their teams work holistically to achieve the best outcome for that product.

The sector showed confidence in its ability to achieve its application development targets. Higher-than-average proportions of respondents felt they always or almost always have sufficient testing tools and methods (64%), that their requirements are clearly defined (57%), and that end-to-end automation from build to deployment is in place (53%). Similar confidence is evident in relation to perceived success in testing key applications. Almost two-thirds of financial sector respondents (64%) said that they have the right level of test automation – a subject to which we shall return – and

exactly the same proportion also said they have the right QA and test expertise. The majority of them also felt they meet their quality goals, and that they have the right testing strategy and methodology.

Key factors

What are the conditions that contribute to increased efficiency in testing? By some margin, the factor rated vital by most of the sector's respondents (71%) was having the right staff with adequate skills. This was a higher proportion than that seen in any other sector in this year's report. Almost two-thirds (64%) rated the need for better communications and collaboration across the lifecycle, corroborating the point we made just now about holistic teamwork. Also of note was the fact that the majority of respondents emphasized shift left (54%) and shift right (53%) testing. We have frequently been seeing these trends ramping up in the field lately.

We also asked people to take stock of the most important factors in the post-COVID world. The usual issues such as CX validation, security validation, and QA automation were mentioned, but areas that were more directly influenced by life in lockdown included remote access to test systems and test environments, and better collaboration tools.

The issue rated highly (52%) by most respondents was the need to improve the productivity monitoring of remote teams. We feel there may be two factors at work here. One is that the sheer size of transaction volumes makes productivity tracking advisable, and the other is that remote monitoring may sometimes be in place for reasons other than just productivity. Financial services are a highly sensitive field, and monitoring can be not just a security safeguard, but a demonstration of due diligence.

Consistent progress in agile, DevOps, test automation…

The financial services sector's early adoption of agile and DevOps has been paying off. This year's survey data shows consistent improvements in quality of software, productivity, cost of quality, and speed to market, with around two-thirds of respondents (64%–66%) reporting excellent or very good improvements. It's also a good sign that a much lower-than-average proportion of them reported a lack of professional test expertise in their agile teams. It's a further indication of the trend towards multi-skilling we noted earlier.

Factors that the sector deemed critical for successful agile and DevOps adoption largely relate to skills, knowledge, experience, and mindset. They included knowledge of the technology stack, a sense of the business's priorities, the skill set, and the degree of flexibility in the culture of the organization.

Similar levels of confidence are apparent as far as test automation is concerned. The number of respondents saying they get a return on investment from their efforts in this area has risen slightly since last year, and the proportion saying they have the right skilled and experienced test automation resources has risen a great deal – from 45% in 2020 to 56% this year.

Aside from ROI, other perceived benefits are also high. The financial services sector was at or near the top of all the sectors assessed in this year's report, with high numbers of respondents reporting benefits: in better control and transparency of their test activities, in reduction of test cycle times, and in the early detection of defects in the testing lifecycle (shift left).

Given these good results, it's no surprise to see quite how keen financial services organizations are to build momentum. In response to a question about their plans for next year, they reported they are highly likely to use automation techniques in every stated category – and to a significantly greater degree than average in each case. Planned areas included headless automation, test environment virtualization, self-healing using AI and machine learning (ML), task-based robotics automation, and pipeline automation.

… and in AI, ML, and test environments

In general, innovations establish themselves as people grow comfortable with them, and the use of AI and ML in quality assurance is a case in point. In some other sectors, such as the public sector and government, we've observed signs of reluctance, but that's not the way things are here. Almost half (49%) of financial sector respondents said their organizations are willing to act on intelligence provided by their AI/ML platform, and the same proportion said they have an established repository of the test execution data that the AI/ML platform needs.

Once again, we see the sector keen to push forward in an area in which it is clearly already making good progress. Around three-quarters of financial services respondents are enthusiastic about their plans for AI in testing. Their plans include using more smart dashboards (78%); using AI systems to store and reuse important domain knowledge (also 78%); and using AI to generate test environments and test data (75%), which is an area in which general progress is also being made. For example, more than half the sector's respondents are highly satisfied with their teams' ability to modernize their test environments in the cloud, and with containers (55%); with their ability to set up fit-for-purpose test environments (53%); and with their ability to configure those environments in a robust manner (54%).

Fulfilling the future

In recent years, we've seen several trends at work in financial services. User behavior has changed. People have more information available to them, which they can access independently and rapidly, and which means they interact differently with their banks and their insurers. This, in turn, means that financial services providers have had to adapt. Face-to-face contact is dwindling, and so the need for bricks and mortar is diminishing.

And then the pandemic came – and the rate of these changes accelerated almost overnight. Banks and insurers and capital markets businesses put their disaster recovery and business continuity plans to the test, and found everything worked just fine. It's a sector in which online transactions and remote access will dominate more than ever, which is better not just for customers, but for the work-life balance of the sector's employees, and for the environment, too.

Making it all work is going to be a continuing challenge. Financial services providers are going to need to meet customer expectations that both change and grow while maintaining security, stability and internal integrity – and for all this to happen, quality assurance will need to be at the forefront. It's good to know that, on the evidence of this year's survey data, that's exactly where it already seems to be.

Healthcare and life sciences

Resuming – and increasing – the pace of development

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Since its arrival, the global pandemic has of course made a significant impact on every business sector – but what perhaps has set healthcare and life sciences apart from other industries is that, while they have had to adjust to circumstances like everyone else, they have also at the same time had to tackle both the causes and the consequences of the outbreak. It's a major health issue, and so of course the buck stops here.

That's why in last year's report we noted there were pressures on the sector's QA teams to deliver. In order to deliver quality at speed, we observed a growth in the adoption of test automation and of artificial intelligence (AI), and a push towards continuous, zero-touch testing, enabled by increasingly working within agile and DevOps environments.

However, it seems to us that, since the snapshot of last year's survey, the momentum in these areas was lost for several months. We saw a lull in developments in robotic process automation (RPA) and in AI, and it was only from around the second quarter of 2021 that things started to pick up again. The gradual return to growth that we've seen coincided with the gathering of data for this year's report, so it has been interesting for us to see if our own qualitative assessment is in line with the survey findings.

Optimism and confidence

As usual, this year's survey started by inviting organizations to give their general impressions. When asked about the importance of different aspects of their IT strategy overall, our respondents in healthcare and life sciences weighted most options quite heavily. For example, the importance of enhancing customer experience, of high responsiveness to business demands, and of high quality in software solutions were all rated highly by 63% of them – which was, in two of these three instances, higher than our survey average. The importance of enhancing security was rated highly by 61% of the sector, which surprised us a little: given the sensitivity of this market, we would have expected it to be an area of significant focus for more of them.

Similarly, most objectives were rated higher than average in the context of testing and quality assurance (QA) specifically. As we noted last year, and as we ourselves currently see in the field, achieving quality at speed, and making QA and testing a smarter, automated process, were both regarded as vital.

How well do people feel application development is going in the sector? The answer seems to be: pretty well. A significant proportion (59%) of respondents in the sector said requirements

are clearly defined, against a survey-wide average of 53%. A full two-thirds (66%) said that activities across distributed teams are well orchestrated and integrated – largely, we feel, because most healthcare sector activities are conducted onshore.

Overall, we feel these responses indicate a higher degree of confidence than we would expect. The same is true of the largely upbeat mood of respondents in relation to their achievements in testing key applications. This may be because there are marked differences between working practices in the area being covered here. For example, while life sciences organizations pursue bespoke developments, making QA more complex and more costly, healthcare practitioners tend to make use of packaged solutions, which are easier to centralize and support. There are marked regional differences, too. Anyone active in this sector who is conscious of a mismatch between the positivity of responses and their own experiences will probably, like us, see why it's happening.

People responsible for QA in the sector are looking ahead. As noted in our introduction, in last year's survey we observed a push towards continuous testing. This year's responses show that 29% of respondents are focusing on integration and on end-to-end testing – but that 50% plan to focus most of their effort on this area two years from now. This is a substantial increase, and we feel its achievement will be facilitated by the growing adoption of agile and DevOps environments, to which we shall come in a moment.

Last year's observations are also corroborated by the high number (49%) of respondents in the sector who said that to make testing more efficient, it will be vital to increase the level of test automation. After the lull we noted earlier, we do see momentum building in the field for this area.

This increased pace is due in part to our collective emergence from the world of COVID-19, and in addition to automation, our survey shows increased focus in healthcare and life sciences on traditional areas such as security validation (ranked high by 49% of respondents), and also such as disaster recovery and resilience testing, which at 35% we would have expected to be higher.

Factors in agile and DevOps adoption

We have already remarked on the increasing appetite in the sector for agile and DevOps models, so it's useful to know what people perceived to be the challenges in making it happen. Half (50%) of them in this year's survey referred to a lack of professional test expertise in their agile teams, and almost as many (47%) mentioned the difficulty in getting the right test environments and test data. The requisite skillsets and test environments are indeed hard to acquire, and we see the demand is rising. For instance, in a later question, significantly higher-than-average numbers in the sector pointed to needs in knowledge of CI/CD pipeline tools (40%), and in development skills (42%).

To speed up and improve testing outcomes, healthcare and life sciences organizations are increasingly turning to smart methods. Well over half (56%) of respondents in this sector said they use AI over past cycles to optimize their test cases, and as many as 60% said they implement smart or automated dashboards to enable their continuous quality monitoring efforts. Both these responses are significantly higher than the overall survey averages.

It's interesting to see what respondents considered the critical factors to be in successful agile and DevOps adoption. In fact, not just interesting, but encouraging: the highest-rated factors for healthcare and life sciences respondents were executive support (59%), business priorities (58%), and a culture that is open to change (53%). What we see here are organizations driven less by the technology, and more by the needs of the business.

Test automation and smart technologies

The enthusiasm in the sector for test automation is corroborated in this year's survey data. Almost two-thirds (64%) of respondents said they get a return on investment from their automation efforts, against just 50% across our survey as a whole. We also see significant stated benefits in reductions of test cycle times, in reductions in overall security risk, and in better test coverage, all at 56%, and all several percentage points above the survey averages.

To maintain the momentum in test automation, organizations in these sectors are looking to invest in appropriate skills. Those deemed by our respondents to be vital included DevOps and CI/CD skills (58%), RPA skills (56%), and AI and machine learning skills (61%), all of which we see replicated in the field.

Plans for the use of AI in testing are quite robust in this sector. Over three-quarters of respondents (77%) said that testing with and of AI forms the strongest current growth area of their test activities, and even higher proportions said AI will be used to generate test environments and test data (81%) and that AI technologies will be used to build self-healing test automation (79%). We see evidence of these intentions in the field.

TEM/TDM: work in progress

The development, management, and use of test environments and test data is often a challenge, and although there are signs of progress in this quarter among healthcare and life sciences organizations, there is still some distance to travel.

Respondents told us that, on average, almost a quarter (23%) of their testing now occurs in cloud-based permanent test environments, and that 17% of testing occurs using virtualized interfaces in test environments. In addition, 16% of testing was said to occur in containerized environments. Although these figures are similar to survey-wide averages, we would have expected them to be higher for this sector. We certainly see more implementations in the field than these figures would suggest.

A question about satisfaction with progress in this area produced a mixed picture. In some cases, there is less confidence in this respect than we saw earlier for test automation or AI. For example, fewer than half of them (45%) are fully convinced of their ability to set up test environments that are fit for purpose, against a survey-wide average of 52%.

Taking stock

In general, then, we can say that after a hiatus in some areas over the last year, the pace of development has been gathering once more for healthcare and life sciences organizations. They are keen to make progress in areas that will deliver higher levels of quality at greater speed; they are as focused as ever on security and compliance issues; software developments in general, and test environments in particular, are increasingly moving to the cloud; and finally – and importantly – we are seeing a growing emphasis on the importance of business outcomes.

When the business under discussion is that of protecting and improving the quality of human life, that has to be a good thing.

High-tech

A sector that blazes trails

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It's always been both reasonable and safe to assume that the high-tech industry acts as a trailblazer for most other sectors, if not all of them. That remains true this year. Again, we see high-tech organizations forging ahead in evolving areas of quality engineering (QE), including intelligent test automation and use of artificial intelligence (AI) and machine learning (ML). Once again, we see an emphasis on factors affecting competitive business performance, including user experience (UX) testing.

That's not to say nothing has changed. In the field, we've seen the sector shift towards open-source tooling, often for cost-efficiency reasons. We've seen the effects of lockdown, too, in the shape of increased demand for remote access to test labs. In addition, in this year's survey data, there are some differences from last year. As we shall see, these are sometimes the result of emerging trends, and sometimes because the respondent base is a little different this year.

Business focus

The differences we see tend to be in specific areas, but most of the general trends are a constant. Like last year, we find the most important aspects of IT strategy included the higher quality of software solutions, enhancing security, and enhancing the customer experience. As we've noted, the high-tech sector is highly competitive, and UX is crucial.

Most of this year's highly rated testing and QE objectives also followed last year's pattern. They included the detection of defects before go-live, protection of the corporate image, and – once again – the customer experience. In fact, all the testing and QE objectives, including quality at speed, increasing the level of automation, and quality enablement, scored pretty evenly, indicating that respondents in this sector placed mostly equal emphasis on them all.

However, the one noticeable difference is that last year, making a contribution to business outcomes stood out from the rest, and this year, it doesn't. We suspect that this may be the first instance in which changes to the survey base are evident. Last year, our sector sample included a higher proportion of organizations in aerospace and defense; this year, we have reduced them in number, and have at the same time included more startups in the mix.

In general, levels of confidence are high in this sector, with a greater-than-average number of respondents reporting that their testing covers all that is needed, that activities across distributed teams are well orchestrated and integrated, that testing is optimized in terms of speed and cost, and that end-to-end automation from build to deployment is in place.

However, it was interesting to see that a lower-than-average number of the sector's respondents felt that they always or almost always have the right testing strategy, process, or

methodology when they are testing key applications. In our experience, the prevalence of the multi-skilled mindset in high-tech – especially in startups – often means that testing is not the forte of anyone in particular, and so a strategy for its execution is less likely to be in place. Indeed, in a later question on the use of AI in testing, we see a higher-than-average proportion of high-tech respondents reporting a skills gap in test strategy and test design skills. There is clearly an awareness here that, as smart approaches establish themselves in QE, there will need to be a greater focus on this area in its own right.

What should the areas of focus include in the post-COVID world? It was no surprise to see a higher-than-average number of the sector's respondents (51%) giving a high ranking to remote access to test systems and test environments. As we mentioned in the introduction, this is a trend we have ourselves seen in the field.

Moving ahead in agile and DevOps…

The adoption of agile and DevOps has continued apace in the high-tech sector. As a result, around two-thirds of respondents this year reported excellent or very good improvements in quality of software, in productivity, in cost of quality, and in speed to market.

To achieve these improvements, and to accelerate and optimize testing, organizations are employing a number of approaches. For the high-tech sector, the most popular approach (frequently used by 55% of respondents) was shift-left testing, which we see in the field, and which makes sense to us.

One of the general benefits of the agile approach is that team members have rounded skills. However, as we observed just now, this doesn't always mean there is depth to those skills. For the high-tech sector, we see that the greatest challenge for testing in an agile environment is the lack of professional test expertise in teams. The high ranking by 50% of the sectors respondents is substantially ahead of the survey average, and in a follow-up question, we see that perceived skills gaps have, on average, risen several percentage points on their 2020 levels. This issue applies to start-ups, in particular. We suspect that to a large extent, this is simply because the technology is a moving target.

… and in TEM and TDM

Progress is evident in test environment management (TEM) and test data management (TDM). As a testing efficiency practice, 61% of respondents highlighted the importance of enhancing test data generation and provisioning solutions for their teams. Indeed, in a later question, we see high frequencies of usage of various test data practices, among which the use of test data management tools was significantly above average. By contrast, just under half (48%) of the sector's respondents said they always or almost always use a dedicated test data support team to provide test data as a service, against a survey-wide average of 55%. We suspect this is further evidence of the generalist nature of the sector's software development and test teams: rather than having dedicated people with test data skills, they are relying on tools.

A much lower 45% saw the enhancement of test environment provisioning solutions as essential to testing efficiency, although we feel this may be because, for many organizations in the sector, this is an issue that has already been resolved. Evidence in the survey bears this out: in a question on the achievement of test environment targets, high-tech respondents reported higher-than-average satisfaction levels in every case. These targets included the ability to set up fit-for-purpose test environments; the modernization of environments with approaches including the cloud and containers; and both the availability and visibility of those environments. In addition, a substantial 59% of the sector's respondents – a full ten percentage points higher than the survey average – told us their test data and environments are always available at the right time. Here, once more, we feel we see the influence of the high-tech start-ups who joined our survey cohort this year.

Intelligent test automation, AI/ML, and Intelligent Industry

Advances are also being made in intelligent test automation, in the use of AI and ML in quality assurance and testing, and in the emerging area of the Intelligent Industry.
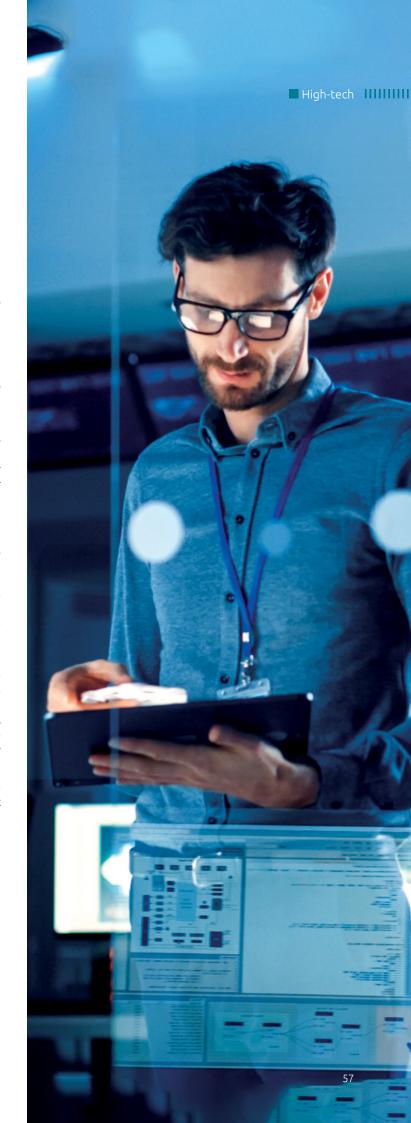
In test automation, substantially higher-than-average numbers of high-tech respondents (56%, against an average of 48%), said they have the right skilled and experienced test automation resources. More of them also reported benefits as a result, including reductions in test cycle time, better test coverage, and reduced test costs. Plans for its future use were also robust. All this, we feel, is because of the nature of this market: by definition, high-tech businesses tend to have a more mature, better, and more technologically literate leadership.

Confidence in the use of AI and ML is also evident. Much higher-than-average numbers of high-tech respondents said they had appropriate repositories of test execution data, and that their organizations were willing to act on intelligence provided by their AI/ML platforms. Here, too, plans for future use were robust, including the use of AI to build self-healing test automation, and the use of smart dashboards.

Intelligent Industry is all about digitizing the key industrial parts of their businesses, and in particular, about using embedded software, data, 5G, edge computing, smart technologies, automation, and the internet of things (IoT). It's therefore no surprise to us that this is an area of focus for high-tech organizations, who – far more than anyone else – emphasize the need to develop team skills in this area.

It's also unsurprising to see the energy that the sector is putting into the prerequisites for implementation here. Once again, we see technologically literate leaders recognizing the importance of their own support and funding, and also of upskilling and proof-of-concept development. What's more, almost two-thirds of them said they would either upgrade their existing test lab to accommodate intelligent industry technologies, or that they would create a new one for that purpose.

Will they do so, though, or will this new area for QE be once again subsumed into the sector's general software development lifecycle? Perhaps it's too early to say. In the meantime, though, there's no denying that this is a market that will continue to blaze trails.

Government and public sector

The importance of outcomes

Jill Harris
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In last year's World Quality Report, we noted that in the midst of a global pandemic, the duty of the public sector to serve its citizens had never been greater. If there is one guaranteed prediction we could have made about the year that has since passed, it would be the continuing truth of this point. The public sector has remained on the front line in the fight against COVID-19, and while policy and practice may have varied from one country to the next, the commitment of public servants worldwide is undeniable. In the area of IT in general, and of software development and test in particular, it has pretty much been business as usual, and working from home hasn't greatly affected productivity.

There has been a downside, though. To maintain the pace, people have changed their working patterns. In many cases, their days have been too long. It's not sustainable, and it needs addressing.

We also observed last year that there was an emphasis in the sector on shift left, as well as on automation. In both instances, we feel that the sector understands the terminology better now, and is making progress.

However, there are caveats as far as test automation is concerned. In our experience, too many people regard it as a panacea, when they should be thinking of it – and using it – far more judiciously. It's about automating the right things, at the right time, and in the right place.

In fact, we might make the even broader point that testing is itself not the be-all and end-all, either. If quality assurance (QA) is the objective, testing is just one means to that end. Public sector bodies – and indeed, all organizations – need also to ask themselves other questions. Is our schedule right? Is our approach to the assessment and management of risk right? Am I doing the right things for the right reasons?

Implicit in this thinking is first, a shift to the left, and second – and even more importantly – a focus on business outcomes. Which is, of course, just as it should be.

Value is more important than volume

We see this business-outcome, customer-focused mindset in evidence as we start to explore this year's survey data. Senior figures in the public sector were asked to assess the importance of various aspects of their IT strategy, and as we would expect, the highest-rated were enhancing security (63% of respondents), enhancing the customer experience (58%), and achieving higher quality of software solutions (57%). Security is of course always significant, and remote working during lockdown has increased its importance.

Responses to a further question seem to corroborate our point about testing being only part of the QA picture. It's a point that doesn't yet seem to have been fully absorbed. How often, we asked, do you and your teams succeed in achieving various application development targets? As many as two-thirds (67%) of public sector respondents said their testing was always or virtually always complete, while a significantly lower-than-average 39% of them could be as confident that their testing was optimized in terms of speed and cost. We infer from this that much testing is being measured in terms of how much of it is being done, rather than in terms of the value it brings. In short, you can't weigh quality by the kilo – or if you prefer, by the pound.

The confidence in testing completeness is matched by the self-assurance we see in the ability of teams to achieve their targets for testing key applications. Higher-than-average numbers of people in the public sector said they always or almost always have the right QA and test expertise (64%), the right testing strategy, process, or methodology (63%), and sufficient test environments available when required (61%). All this may well be the case – but does any of it necessarily mean they are achieving the right business outcomes?

Looking ahead

There's evidence the emphasis may be improving in this respect. When asked to compare current quality efforts against those anticipated two years from now, the biggest change by far related to acceptance testing. A quarter of public sector respondents (25%) said it was an area of focus now – but 62% said it would be in two years' time. It's encouraging to think this might indicate that increased attention will be given to business outcomes.
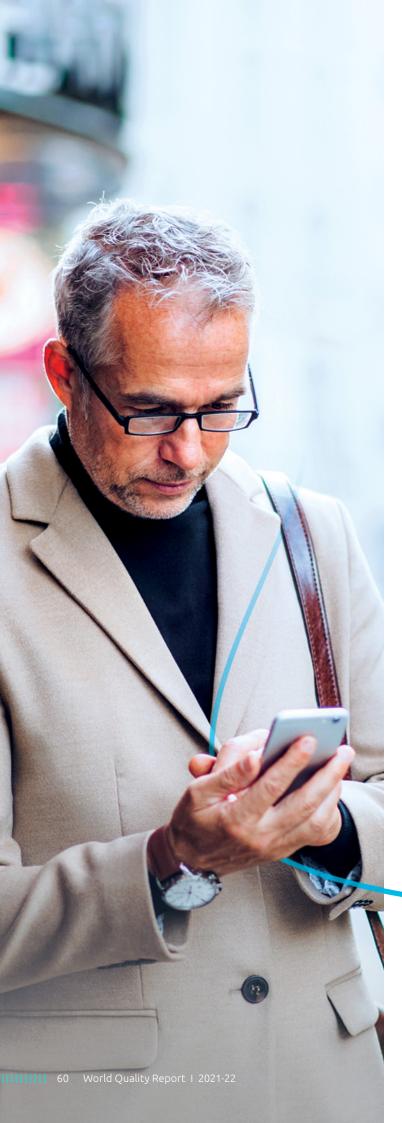
We also asked respondents to look ahead in another way: which areas, we wondered, needed more focus in the post-COVID world? Given the effects of lockdown, we weren't surprised to see the highest response was for remote access to test systems and test environments (48% of respondents). The high proportion (47%) who earmarked customer experience validation and usability testing was good to see, but we thought the fact that as many as 44% mentioned the importance of improving the productivity monitoring of remote teams was surprising, and even a little disappointing. Anything that implies employer distrust runs the risk of alienating team members.

Gauging progress in agile, DevOps, and test automation

It was good to see half the sector's respondents (50%) saying they always or almost always shift left, but it was disconcerting to note people's views on the areas in which the adoption of agile and DevOps had delivered the greatest improvements. Over two-thirds (68%) saw excellent or major gains in productivity, but significantly fewer (59%) could say the same of the quality of their software. The implication here is that while some organizations aren't doing their best work, they can at least say they are doing it quickly. Once again, it's a question of whether the emphasis is sufficiently on business outcomes.

Which metrics are public sector teams using to track the quality of applications? Methods always or frequently used included risk coverage by test (47% of the sector's respondents), requirement coverage by test (44%), and percentage of tests failed or passed (also 44%). These results were in line with our expectations, although at 46%, we would have hoped to see the monitoring of defect leakage into production score more highly.

There were some curiosities in people's assessments of skills areas in QA and test. As many as 20% of them said that data analytics and AI skills were of less relevance. This is an odd take for what is clearly a growth area. In fact, in a later question, we see reports of significantly lower-than-average progress in this field. For example, only 30% agreed they have an established repository of the test execution data required by AI and machine learning (ML) platforms, against a survey-wide average of 48%. And again, only 30% agreed they have identified applications or

programs that would benefit from AI or ML, against a survey-wide figure of 42%. These low numbers reflect what we see in the field, but we know that many in the sector do want to take strides in this area – which is why it's so puzzling to see one in five of them saying the requisite skills are of less relevance.

Other skills oddities included the 28% who said collaboration skills were less relevant, and the 25% who said the same of test case design skills. Designing test cases is important. It involves thinking ahead to outcomes, and to the metrics that gauge them.

We noted earlier that the sector was making progress in test automation, but this year's data tells a different story. For example, only 28% of respondents felt their applications have achieved the level of stability needed for test automation – against an average of as much as 47% for our survey as a whole. This could be because the base size for this question was low, and/or because answers were specifically and only from QA and testing managers. It's possible and perhaps even likely that the people on the ground are less sanguine about progress than their superiors.

Focus on the results that matter

Where does all this leave us? In general, we feel, this year's data takes us back to one of the main points with which we started this analysis: the point that the focus of QA and testing effort, for this sector and indeed for every other, should be outcome-driven. Fewer than half (42%) of respondents in the public sector said that business priorities were essential for successful agile and DevOps adoption. Whether organizations are working in these development environments or in others, we'd like to think that in years to come, this proportion will grow – and grow significantly.

Telecom, media, and entertainment

Making progress in industries on which the world depends

Paul Collins
Practice Manager, Digital Assurance
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The telecommunications, media and entertainment (TME) sectors are an interesting hybrid, in that they are simultaneously subject to consumer pressures – all those smartphones, all those streaming services – and to commercial and regulatory pressures from the many other industries, including financial services, that depend on them. As a result, and as we also noted last year, this is an area that needs to move forward particularly fast. The emphasis is on competitiveness, and hence in turn on time to market, on highly integrated systems, and on emerging technologies such as artificial intelligence (AI) and the internet of things (IoT), and also, specifically in quality assurance (QA), on intelligent test automation.

Customers, time, and efficiency factors

Given these prevailing market conditions, it's no surprise to see that, once again this year, the most important aspects of IT strategy were deemed by TME respondents to be enhancing customer experience and enhancing security. For testing and QA in particular, one of the most important objectives was, as we would expect, quality at speed, which was rated highly by

61% of the sectors' respondents, against 54% of them last year. In fact, it's interesting to note that this year, all the testing and QA objectives were rated highly. Detection of defects before go-live, supporting everyone in the team to achieve higher quality, making QA smarter and more automated, supporting business outcomes, ensuring end-user satisfaction – it's no wonder all these achieved such positive ratings.

Respondents were more sanguine than most about the extent to which they are achieving their application development targets. Higher-than-average numbers of them said they always or almost always cover all that is needed, that activities across distributed teams are well orchestrated and integrated, and that the testing tools and methods they need are sufficient and available. If anything, we would expect figures for this last option to grow in the years to come.

It did surprise us, though, that over half the respondents in TME (51%) felt their requirements are clearly defined. In telecommunications in particular, this is not what we see. Organizations in this market are under great time pressures – for instance, to deliver 5G-optimized apps ahead of the competition – and so they tend to watch early adopters and then rush to catch up. These are not circumstances in which it's always possible to define requirements that clearly.

Confidence is also evident in responses to the achievement of various targets when testing key applications. Higher-than-average numbers of TME respondents felt they always or almost always have the right level of test automation, the right QA and test expertise, and that they meet their quality goals.

The number of them who felt they have sufficient test environments available when required has risen since last year. This, we feel, is probably because of cloud adoption. Indeed, elsewhere in this year's survey data, we see that higher-than-average numbers of TME respondents were highly satisfied with their ability to set up fit-for-purpose test environments, with the visibility of those environments, and with their timely availability.

Growth in this area is probably explained by the extent to which enhancing the provisioning of these environments is seen as a key efficiency measure. In a question on testing efficiency measures, 60% of TME respondents said it was vital, against a survey average of just 48%.

Telecommunications, media and entertainment businesses are also ahead of the game in test data practices. For example, we see them leading the field in the extent to which they create small sets of test data that are dedicated to each sprint, and in the presence of dedicated teams to provide test data as a service. In fact, as many as 60% of them – against a survey average of 53% – said they have sufficient test data for all their testing. It's true: in telco and in media markets, there is indeed a great deal of raw data.

Beyond test environments and test data, other key efficiency criteria were also to be expected. They included the need for skills, the need for adequate test data generation and provisioning solutions, and the importance of shift right testing. In this last case, we feel the high rating was because in the TME sectors, QA is fairly well integrated into the software development lifecycle, including at the end stage, where shift right comes into play.

The need for better communication and collaboration across the lifecycle, which was another high-scoring efficiency criterion, is also the result of this holistic response to development and test – but in our view, it's still important to ensure that QA maintains some of its own discrete identity.

Benefits in agile and DevOps adoption

The adoption of agile and DevOps continues to grow. In the field, we've noted a related rise in continuous testing, largely to keep pace with the frequent releases to which telecom, in particular, is prone.

This is probably why almost half TME respondents (48%) told us that, in their agile and DevOps developments, they always or almost always integrate test as automatic quality gates in the CI/CD pipeline in order to accelerate and optimize their testing. We expect this proportion to rise over the next year or two.

It's encouraging to see that in most cases, perceived skills gaps in TME are lower than average. In our experience, the skills base in these markets is more advanced than in many other sectors, and this year's data bears that out. For instance, TME's stated need for knowledge of CI/CD pipeline tools, for development skills, and for test case design skills, are among the lowest we see this year.

This probably explains why skill sets were the highest rated agile and DevOps critical success factor: organizations in these sectors recognize their importance more than most. Another area deemed crucial to success was executive support: change management is vital in these markets, where ensuring team and consumer buy-in is as important as the innovation itself.

In general, TME organizations are seeing significant advantages as a result of agile and DevOps adoption. Respondents reported excellent or very good improvements in quality of software, productivity, and speed to market – and over three-quarters of them (77%) said they'd seen improvements of 11% or more in cost of quality, which is the highest proportion of respondents we've seen in this year's survey. Cost is a big factor for telco and media consumers, and hence for the businesses that serve them, and it's likely that the improvements we see here are at least partly the result of the adoption of managed services.

Getting smart in test automation, AI, and ML

In our introduction, we noted that the competitiveness of these markets has prompted various technological developments. One of them was intelligent test automation, and this year's survey data shows that TME respondents are seeing a number of benefits as a result of its implementation. The most commonly reported benefit was better control and transparency of test activities, although once again we also see a cost-related issue featuring prominently: over half of TME respondents (52%) said automation had delivered test cost reductions.

A further growth area that we namechecked was the use of AI, and once again, this year's survey data bears that out. Higher-than-average numbers of TME respondents said they have the established repository of test execution data that an AI and machine learning (ML) platform requires, and that their organizations are willing to act on the intelligence it provides. In our view, smart technologies are at their best in these sectors when they are used to augment human decision making.

Embracing the intelligent industry

The final section of this year's survey addressed the intelligent industry, which is about organizations digitizing the key industrial parts of their businesses, and in particular, about using embedded software, data, 5G, edge computing, smart technologies, automation, and the internet of things (IoT). We've already noted that emerging technologies such as these are important for TME, so it's not surprising to see these sectors placing high emphasis on the drivers for their adoption, including improved productivity and efficiency, increased service and product quality, and (of course) enhanced customer experience. Nor is it a surprise to see leadership support and funding being seen as a prerequisite for success: as we noted earlier, substantial change can't be achieved without direction from the top.

A further prerequisite is adequate QA facilities. Most respondents told us they would either upgrade their existing test labs, create a new, dedicated one, or partner with someone else. Whatever their chosen route, we feel it highly likely that many TME organizations will be working with a third party on a managed services basis. In these sectors, that's an approach with which businesses are comfortable.

A bedrock on which the world can build

It's no exaggeration to say that, from early in 2020 right up to now, the telecommunications, media, and entertainment sectors have made a substantial difference to the effects of the global pandemic. Lockdown leisure time has been one instance, but it's minor when set against others. For instance, without the advances made in telecom in recent years, it would have been harder for many people to work from home – and if they had been obliged to commute, and to engage with others face to face, it's likely there would have been far more infections, and even higher death tolls.

We owe these industries a debt of gratitude – and it's only right that when we see the great strides they are making in testing and quality assurance, we applaud their efforts, and wish them well in maintaining the momentum.

ABOUT
THE STUDY

WORLD QUALITY REPORT 2021-22

The World Quality Report 2021-22 is based on research findings from 1,750 interviews carried out during April and May 2021 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 37 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 also included companies having less than 1,000 employees (in the respondent's national market) – with an objective to get inputs from the start-up segment in order 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 Hi-Tech companies and start-ups , we are able to bring in their views and insights in the space of product, engineering and digital manufacturing services for Automotive, HealthCare and Life Sciences and High-Tech Sector.
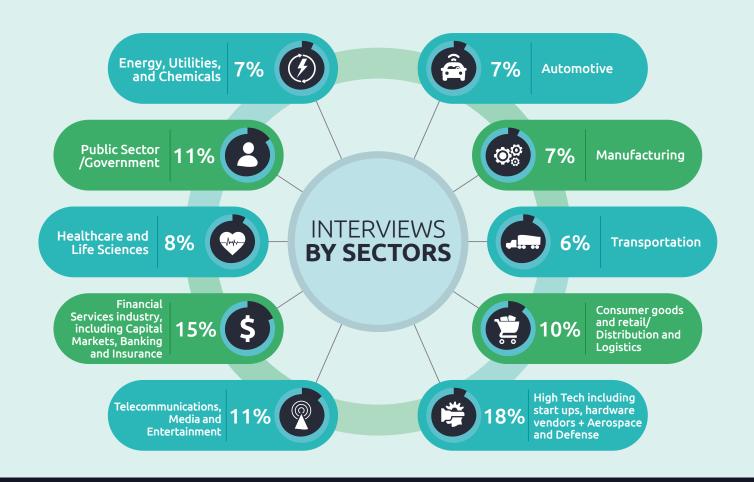
To ensure a robust and substantive market research study, the recruited sample must be statistically representative of the population in terms of its size and demographic profile.

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 2021-22 is based on a sample of 1,750 interviews from enterprises with more than 1,000 employees (26%), organizations with more than 5000 employees (34%) and companies with more than 10000 employees (40%). The approach and sample size used for the research this year enables direct comparisons of the current results to be made with previous research studies conducted for the report, where the same question was asked.

During the interviews, the research questions asked of each participant were linked to the respondent's job title and the answers he/she provided to previous questions where applicable. For this reason, the base number of respondents for each survey question shown in the graphs is not always the full 1,750 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 37 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

- **Energy, Utilities, and Chemicals** — 7%
- **Automotive** — 7%
- **Public Sector /Government** — 11%
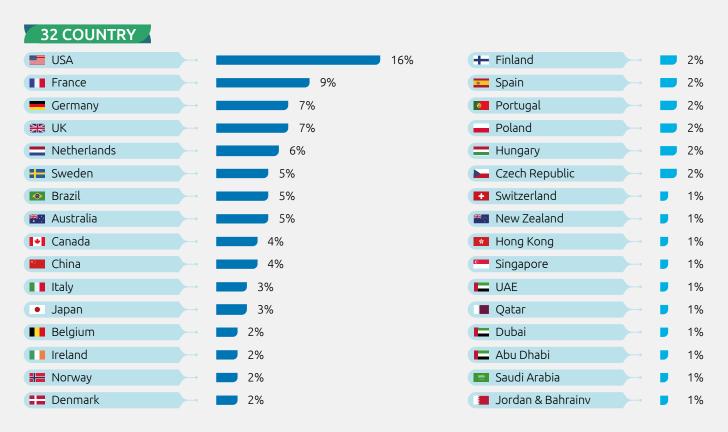- **Manufacturing** — 7%
- **Healthcare and Life Sciences** — 8%
- **Transportation** — 6%
- **Financial Services industry, including Capital Markets, Banking and Insurance** — 15%
- **Consumer goods and retail/ Distribution and Logistics** — 10%
- **Telecommunications, Media and Entertainment** — 11%
- **High Tech including start ups, hardware vendors + Aerospace and Defense** — 18%

INTERVIEWS BY JOB TITLE

Job Title	Percentage
CIOs	24%
QA Testing Manager	18%
IT Directors	17%
VP Applications	15%
CTO / Product Head	10%
VP / Director of R&D	10%
CMO / CDO	6%

INTERVIEWS BY COUNTRY

1750 TOTAL

350 North America	
125 Southern EU	
305 Western Europe	
175 Nordics	
90 Eastern Europe	
170 South East Asia	

100 Australia & New Zealand	
65 Middle East Asia	
135 BeNeLux	
155 UK and Ireland	
80 LATAM	

32 COUNTRY

Country	%		Country	%
🇺🇸 USA	16%		🇫🇮 Finland	2%
🇫🇷 France	9%		🇪🇸 Spain	2%
🇩🇪 Germany	7%		🇵🇹 Portugal	2%
🇬🇧 UK	7%		🇵🇱 Poland	2%
🇳🇱 Netherlands	6%		🇭🇺 Hungary	2%
🇸🇪 Sweden	5%		🇨🇿 Czech Republic	2%
🇧🇷 Brazil	5%		🇨🇭 Switzerland	1%
🇦🇺 Australia	5%		🇳🇿 New Zealand	1%
🇨🇦 Canada	4%		🇭🇰 Hong Kong	1%
🇨🇳 China	4%		🇸🇬 Singapore	1%
🇮🇹 Italy	3%		🇦🇪 UAE	1%
🇯🇵 Japan	3%		🇶🇦 Qatar	1%
🇧🇪 Belgium	2%		🇦🇪 Dubai	1%
🇮🇪 Ireland	2%		🇦🇪 Abu Dhabi	1%
🇳🇴 Norway	2%		🇸🇦 Saudi Arabia	1%
🇩🇰 Denmark	2%		🇧🇭 Jordan & Bahrainv	1%

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WORLD QUALITY REPORT 2021-22

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Micro Focus is one of the world's largest enterprise software providers. We deliver mission-critical technology that helps more than 40,000 customers worldwide manage core IT elements of their business. Strengthened by a top-10 patent portfolio, our broad set of technology for security, application delivery, IT operations, governance, modernization, and analytics provides the innovative solutions organizations need to run and transform—at the same time.

Our application delivery capabilities reliably scale Agile and DevOps practices across all environments, from mainframe to cloud—quickly bringing innovative ideas to life at the pace digital business demands. But more importantly, we enable software delivery organizations and quality assurance teams to balance the often-opposing forces of producing high-quality software with immediate delivery. Our continuous quality and testing solutions are unparalleled in the market and help thousands of organizations to intelligently scale automated testing as part of the software delivery pipeline, provide immediate feedback on business risk from development to release, and increase delivery velocity and customer satisfaction.

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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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