



SAFETY 2027

Conformity Assessment in a
Digitalized and Adaptive World

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MANAGEMENT SUMMARY

Safety 2027

As a result of digitalization, all everyday objects, infrastructure, and means of production will be connected in the near future. This complexity of variable interfaces will pose a great challenge for safety providers, especially in the TIC industry. The present study describes the most important changes in the coming ten years and provides strategic recommendations for players in the TIC sector.

Safety 2027

Global TIC markets are growing rapidly, and the industry is faced with new challenges thanks to the Internet of Things. Safety and security are no longer sufficient for defining security; prevention emerges.

Test Objects

Products and technological equipment will become digital, individual, and adaptive; new, and especially virtual, objects will be added. The demands placed on existing test objects will increase, especially concerning the testing of persons.

Processes & Business Models

Testing, inspecting, and certifying as a one-time event with enduring results will transform to become a continuous and data-driven process. New business models emerge through digital layers and artificial intelligence.

Customers & Communication

Trust will gain a new meaning in the digital world. The TIC industry will implement omnichannel management for smooth data- and customer management – right down to the end consumers.

Recommendations for industry

- #1 Establish and use feedback channels.
- #2 Offer every customer security by design.
- #3 Create contact layers.

Recommendations for the TIC sector

- #1 Position yourself as the digital safety assistant for your customers.
- #2 Also position yourself as the digital safety assistant for your end customers.
- #3 Establish omnichannel communication.
- #4 Rely on business partnerships.
- #5 Constantly develop alternative business models.
- #6 Rely on data-driven predictive maintenance.
- #7 Understand experts and auditors as human / machine organisms.
- #8 Organize all your company activities in a project-based and agile manner.
- #9 Launch joint ventures with leading developers of simulation software and blockchain tech.
- #10 Build up competence in the field of artificial intelligence.

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Foreword

Dear Readers,

Even linguistically, the term “seal” carries weight. If something has a seal affixed to it, it is considered decided, final, unavoidable. No matter whether a seal of approval, a certification seal, or simply a seal of secrecy – the word resonates with a sense of respect for the decisions of worldly and religious rulers, invested with eternal value through sealing wax and signet.

Today’s testing institutes have long since dropped the sealing wax. In the technologically highly complex world of the 20th century, they developed quality standards and tested the compliance of these standards – thus creating safety for manufacturers and trust for customers.

The TIC (Testing, Inspection and Certification) industry now faces the challenges of the 21st century: virtual products, individualized products, products and technical facilities that are co-designed by customers or constantly adapt to their situational needs, growing data streams, and increasingly shorter development cycles – and all of this with the demand for the highest degree of safety. Digitalization in particular opens up a host of new business opportunities for the TIC industry, but also implies almost equally as many risks.

This study aims to illuminate both facets: opportunities as well as risks, potential as well as danger. It provides a consistent and empirically based scenario for the TIC industry in ten years’ time. None of this yet carries a seal, none of it inescapable – after all, the focus here is on a future which is still being shaped by all of us. This study names the main drivers for the future of technological safety. It explains what players will drive which trends, and for what reasons. From the roadmaps, plans, and expectations of the major players involved, a picture of the future of the TIC industry emerges for the coming five to ten years.

And, based on concrete strategic options, our study shows what steps you must take to help shape this future.

The trends described in this study are to be understood as long-term aids for strategic orientation. Be sceptical of trend studies which forecast that your industry will completely change overnight. This is nonsense. Most providers will be able to continue their business operations for many years – continue with steadily declining revenues, but continue nonetheless ...

The present study invites you to shape the future. Be encouraged to develop new approaches to the future by conducting manageable pilot projects, thus entering new business areas and acquiring new customers while also generating more profit than is lost by your existing model. Your success in doing this – or lack thereof – will decide whether you will number among the winners or the losers of today’s trends in 2027.

Due to our cooperation with TÜV NORD AG & TÜV SÜD AG, we are able to present this study to you free of charge. Please do not hesitate to contact us or our partners if you would like to use the results of this study to review your strategies. We would love to help.

We expressly wish to thank our study partners for their kind and constructive help. They enabled us scientists to undertake an independent and unbiased analysis of future trends. We wish ourselves and our readers the same open-minded approach to the challenges of the industry as well as an awareness, as we plan our futures, that we can only influence change by actively shaping it.

Make your company future-proof! We would be delighted if this study helps you to do so.

We wish you an inspiring read
... and a great future!



Michael Carl
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2b AHEAD ThinkTank



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2b AHEAD ThinkTank

Greetings

Dear Readers,

The question of whether you can trust a person, an organization, or a product is a perennial one – especially when dealing with someone for the first time or when planning to get involved with a new and innovative technology. In this situation, the opinion of a trusted third party with the right experience is a valuable aid.

Of course it is possible to ask a personal contact to share their experience. However, are they able to fully grasp the complexity of the issue? The TIC (Testing, Inspection and Certification) industry – and especially TÜV NORD and TÜV SÜD with their specific technological expertise – has dedicated itself to answering the question of trustworthiness for its business partners, but also for society, and of substantiating this answer through qualified testing and systematic assessment. The result of this process, ideally, is a certificate or a test mark that creates transparency and trust.

Digitalization is changing our expectations, especially in terms of how quickly and simply information needs to become available. At the same time, information can be reproduced even faster than before, appearing in a huge variety of sources. This can lead us to believe information that we would never have trusted in the past, information we would have recognized and dismissed as an irrelevant individual opinion or even as a false statement.

The TIC industry creates trust that rests on an objective foundation – with the thoroughness and speed appropriate given the complexity of the issue. In this way, TÜV NORD and TÜV SÜD have helped people to trust new technological solutions for



over 150 years now. Our product and system certifications create a solid basis for ensuring that products meet our demands – even those produced half a world away.

In the future as well, we will ensure that you can safely place your trust in new technologies – and in your business partners. The experts interviewed in this trend study portray a fascinating picture of this future and show that, through digitalization, we can continue to offer the best possible support for the process of building trust.

You can look forward to an interesting read! We will make very sure that you can continue to trust our certificates in the years to come!

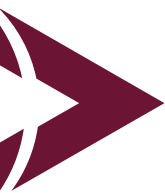
Best regards,

Sandra Gerhartz
 Director
 TÜV NORD CERT GmbH



Dr. Jens Butenandt
 Chief Technology Officer
 TÜV SÜD Product Service





THE STUDY

Trend-cycle analysis, not megatrends

This is not a study on megatrends. Those who work with megatrends do so on the assumption that there are a limited number of drivers that affect all business areas equally. This is wrong. Trends exist only because industry developments are driven forward or blocked by those individuals who have the resources or authority to do so and to lead others in doing so.

Human behavior – and thus also investment decisions – always follows specific interests, desires, and compulsions. These vary by industry and by industry sector. We trend researchers are able to observe this behavior on the part of decision makers; we can try to understand it, we can analyze driving and blocking factors, and we are able to generate forecasts regarding where this behavior on the part of industry players will lead. In the sciences, we call this qualitative research. The following study is based on this approach. Unlike with other industry studies, you will find no lists of percentages in the following pages.

Futurists know that the future can neither be measured nor quantified – because it has not happened yet. For the most dead-on forecast possible regarding what will happen in your industry in the years leading up to 2027, no representative survey of customers or so-called experts will help, no

matter how large-scale it may be – because no matter how many you might interview, they would likewise be helpless to predict a future that has not yet occurred.

The only possible way to come close to a reality that is still in development is to speak with trendsetting companies and industry players who are driving the technologies and trends that we will all meet in the future through the decisions they are making today, because you can talk to these players. Furthermore, you can try to understand their motives and compulsions. You can find out about their expectations and roadmaps for the years to come. And where these players intersect, we can see those trends that are being pushed – or blocked – most forcefully. This provides the basis for the most realistic picture of the future of your industry that researchers could possibly offer you. You will find this picture on the following pages.

The trend research institute the 2b AHEAD ThinkTank specializes in the identification of driving and blocking factors, the analysis of opportunities and risks, and the development and implementation of business models for the future – all individually tailored to the trend cycle of specific companies.

This last feature is important because the players who have a decisive influence on the business of their organizations vary from company to company. Thus the trend drivers and blocking factors, as well as the opportunities and risks, also differ between companies – even within the same industry.

Those who handle their future responsibly will not run after the one-size-fits-all megatrends of supposed trend gurus, but will base their strategies on the goals and the roadmaps of the leading attackers and defenders in their markets. This is our mission. We would be thrilled to hear that this study has helped you succeed there, too.





THE BIG PICTURE

How will living and working environments change by 2027?

The living environments of customers in 2027 will be shaped by many factors. The average life expectancy in Germany, for example, will exceed 85 years and tend towards 90. In many families, celebrating the 100th birthday of a grandparent will have become a normal occurrence. Even among other families, the question will arise: What will people want to do between the ages of 60 and 85? Vacation? Work? Most are sure to experience a sort of new beginning as they enter the third active segment of their lives between 50 and 60. The phrase "new beginning" is meant literally here: a new job, a new home, a new life partner... active living will continue at that point. The arrival of retirement age with its reduced mobility and activity will be pushed even farther back. People will half want this in order to spend those 30 years in a meaningful way, and they will half be forced into it in order to avoid the very real threat of old-age poverty.

People will experience their personal health as the greatest luxury of the future. Thanks to all varieties of body enhancement, health will increasingly become a purchasable consumer good: Medical food will eliminate most illness in society; brainfood will offer the custom-tailored optimization of mental performance, and production of human organs as replacement parts will lead to further increases in life ex-

pectancy, initially in the luxury segment. The next stage will be genetic optimization, which among other goals aims to slow – and finally stop – the aging process.

The world's economy will increasingly be dominated by Chinese players – not only in production, but also in the areas of innovation and conceptual design. Asia will gradually outgrow its role as the region of discount labor, and will begin looking to suit its own growing labor needs in Africa: first in Northern and Southern Africa, and years later in Central Africa as well.

Across the globe, people are streaming from provincial areas into major cities. Rental costs are rising in the booming metropolises while rural areas are slowly being abandoned. Many places, in the meantime, will have experienced a long-predicted transformation: We will then live in an era of full employment. Every person with fairly decent qualifications will have work and what's more: Headhunters will begin to show up at the door every day thanks to the millions of unoccupied positions in many job markets. The companies themselves will see this as a catastrophe. Not so the employees: They will have the upper hand in the employment game for the first time in decades, and thus can freely choose the jobs they want.

will push salaries upward, but will also be cause for the fact that roughly 40% of the working population will change projects – and companies – every 2-3 years as so-called "project workers." The short supply of personnel will also compel companies to develop and communicate their attractiveness as employers in new ways. Against this background, some of the fundamental values of our society will be redefined: Security in life will remain important, but will be determined by new factors in the face of constantly available new jobs. Trust will remain important, but will no longer simply be handed to major brands. In times of maximum transparency, trust will constantly be tested. Expertise will be available round the clock in a world where countless experts – both genuine and self-styled – will strive for recognition in the TIC industry; communication will be the factor that determines who will find an audience.

The greatest change, however, between now and 2027 will find its cause in the rapidly expanding phenomenon of digitalization. In the future, digitalization will permeate all areas of life with information and communications technologies. By ten years from now at the latest, more than 95% of the adult population in Europe and the US will use the internet regularly. The successors to the iPad & Co. will be: iTable, iWallpaper, iMirror, iCar, iShopWindow, iShelf, iTrainSeat and so on. All objects that can thereby obtain new uses will become internet devices. In the future, the Internet of Things will not only encompass individual buildings, but entire cities and even the entire world. Every object will have an IP address.

New human / machine interfaces

At the same time, new, user-friendly usability concepts and new human / machine interfaces will appear. Companies will have to prepare themselves for the time when electronic devices will not only recognize individual customers, but also their current state of emotions, sensitivities, and vital functions. Consumers will grow accustomed to communicating with their devices in a "human way": through language, facial expressions, gestures, and later even

thoughts. Thus customers will also get used to the fact that technology will be capable of assessing their present situation and reacting to it successfully – within fractions of a second. Electronic devices will thus become "more human" than their human counterparts, because they will know much more about their counterparts than the average stranger would! This presents a great risk for human experts and sales representatives, but also a great opportunity for those who know how to use the technology competently.

Devices are better than sales personnel ... They remember you

Indeed, the additional benefits of connected devices in the future will not come about by means of data as we understand it today: those heaps of statistical data now lying in databanks. Our present conception of data will change. The intelligent compilation and evaluation of information on users' dynamic data will also be part of our future understanding of data. Object recognition, image recognition, and observation-capable interfaces will guarantee that, in the future, everyday objects will observe the behavior of their users, combine this real world data with stationary information stored in the cloud, and produce unique and situation-appropriate prognoses regarding the current needs of the user through automated algorithms or business intelligence systems – always accurate down to the second. It remains to be seen to what extent these devices will require an intelligence of their own or will function as part of a "smart grid" through which they are controlled situationally, yet also in a centralized manner. The question of "data" in 2027 will have little to do with the definitions we are accustomed to today. It will mainly be a question of the recognition of the user's needs ... and the advance prediction of their desires.

Smartphones as intelligent assistants – The dawn of the traffic light society

In spite of the rapid expansion of smartphone use and the resulting opportunity for consumers to use all new

apps available, one basic truth of technology- and media use cannot be ignored: Only a small percentage of us are highly active users who proactively seek out, try, and use new applications. The vast majority of the world's population remain couch-potato consumers. An essential future market will thus be systems that function independently of active control on the part of the customer. Such systems "observe" their owners while they go about their daily activities, analyze the data gathered, use it to create "needs profiles," and take these profiles as a foundation for constantly "filtering" the environment of their owners. These systems acquire their "intelligence" through automated data exchange with other nearby devices. In that way, they project suitable (though entirely unsolicited) recommendations into the view of the user when the user finds themselves in an everyday situation that requires making a decision. Software producers do not describe these assistants as "programs," but conglomerates of many individual programs. Most of the necessary data will be gathered from the mobility profiles of the user, which will consider not only the users' physical location, but also, for example, their personal internet habits – their individual behavior as well as their personal environment.

At the same time, we will experience a paradigm shift in the realm of data protection. Naturally, all of the predictions mentioned so far will only take place if people release their personal and user data for this kind of analysis and forecasting. This is highly probable. The assumption that private citizens do not want to release their data is 1980s thinking. Today's population does not want to keep its data secret. Data protection will be important in the future, but also different, meaning that the consumer can view, change, and delete the data saved about them with a single click. There will be a system in place that ensures this. Companies that enjoy the trust of their customers as "trust centers" will have the best chances strategically. No company really wants to annoy its customers with mass advertising that scares 90% of recipients away and is

only useful for the remaining 10%. However, in order to filter out this 10%, companies will have to evaluate consumer data. And for that, they need the trust of their customers. Customers will understand this, because life is much more comfortable when you receive only useful information!

In 2027, people will live in a "traffic light society." They will have grown used to having an electronic assistant on their smartphones (or on the smartphone's successor) for every area of life that gives suitable advice, product evaluations, and tips for every possible situation. Customers, however, will not want to receive all this virtual information as rows of digits or mountains of text, but as images or within conversations. They want to be told: Is this the right product for me or not? In most cases, your customer in the year 2027 will trust their smartphone more than human salespeople. This is a good thing, because the smartphone will give them better answers!

Loss of significance for salespeople ... The devaluation of the expertocracy

Let's not beat around the bush: Digitalization holds not only great opportunities, but also major risks for today's companies. When we look back from 2027, there will not only be big winners in the digital world, but also large numbers of losers as well. For what can sales staff do when customers know better via barcode scanners and Amazon if a particular product is right for them, how other customers have rated it, and if they can get it cheaper around the corner? Today's expert, tomorrow's cashier!

This development will not only affect salespeople. What can teachers do when their students know more than the department of education requires by reading e-books? Today's expert, tomorrow's reciter! What can craftsmen do when homeowners no longer seek advice on heating their houses, but already know from the internet which heating system best to install? Today's expert, tomorrow's handyman! What can tour guides do when there is always someone in the group

who has more to say about the history of local landmarks – thanks to their smart phone – than the guide could ever memorize? Today's expert, tomorrow's chaperon! What will real estate agents do when their clients receive an offer for their dream apartment automatically in their smart glasses as they cross the street? Today's expert, tomorrow's doorman!

In the next few years, we will experience a devaluation – a loss of significance – of the expertocracy that will radically change large segments of our economy and open the way for new markets. Because: Those experts who characterize our world today will have to ask themselves the hard question: Can my expertise be offered faster and better custom-tailored by software in the future? Salespeople who do their work simply in terms of gathering, compiling and passing on data ... will lose. Their share in the market will go to electronic assistants.

But this is no reason to stick our heads in the sand. On the contrary: Those who actively use this trend in their work will be among the winners in tomorrow's business. And the real winners will be those who know how to use the capabilities of digital devices for themselves as electronic assistants and, at the same time, are able to offer their patients and customers services that digital devices cannot. Such effects can already be observed for physicians and lawyers – teachers, salespeople, and other experts will soon need to adapt as well.

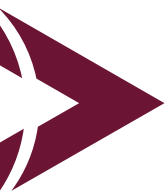
Cutting out the middleman: Blockchain will revolutionize all industries

Another change will be even more drastic. Blockchain technology is a relatively recent achievement in IT history. Traditionally only used to

enable and ensure transactions with cryptocurrencies such as Bitcoin, this technology can potentially eliminate the middleman in every electronic transaction. Data on previous transactions are recorded in "blocks" of the same name, saved in a code, and copied to each device that uses this technology. IT experts across industries agree that – starting in the bank and insurance sector – blockchain technology will disrupt existing business models and institutions.

A high degree of security, derived from several of blockchain's native characteristics, will be a central driver behind the growing dissemination of the technology in the coming years. This can easily be seen from the example of a money transfer from person A to person B. The transfer is represented as a block of code online, is sent to each device in a network, and is verified by each. Then the block is added to the already existing chain of blocks, and thus to other transactions. Decentralized storage and the ability to link blocks with previous and future transactions increases security as information practically becomes impossible to change – it would be necessary to manipulate information on every device in the network. Another advantage is that the contracting partners A and B are always able to determine that money has been transferred: Every transaction gets digitally signed using both a public and a private key for each party involved, ensuring flawless identification.

These transactions must not necessarily be financial ones. The technology is essentially suitable for any kind of information transfer. It potentially serves as "trust provider" in diverse fields, and can transform or even replace the role previously played by entities such as lawyers, banks, or notaries. Blockchain technology and applications – e.g., smart contracts – are expected to spread into various other areas by 2027.



1. SAFETY 2027

How the importance of safety will change the future

Certified safety is a core element of industrial production, applications, and management across all industries. Safety risks must be minimized in order to protect the customers, staff, production facilities, and financial power of companies. Trust here mainly depends on suppliers, traders, and operators that ensure customer safety. This in turn can only be achieved independently through an unbiased third party: the TIC (Testing, Inspection, and Certification) industry with its conformity assessment bodies (CABs), in Germany historically rooted in Technische Überwachungsvereine (TÜV). The overall societal role of this industry goes far beyond offering objective assessment, testing, auditing, inspection, and certification; the sector fills the gap between innovation and progress while guaranteeing safety for all stakeholders. It reduces complexity by providing consulting on the application of norms, and leads to uniform standards for interoperability within the context of safe use. Finally, the industry is a necessary trust provider in every B2B, B2C, and in the future also C2B2C, business relationship.

In (today's) emerging economies, industrial and consumer sectors are growing around the globe, sometimes also sharply – particularly notable are

the fields of energy, food, communication, and mobility. The largest new markets can be found in India and Pakistan. The traditional economic principle of linear and analog growth would suggest that the world market for TIC services will grow rapidly in the face of this development. It would undoubtedly be possible to carry over the safety standards (and the correspondingly rising safety demands) of the Northern Hemisphere to the growing markets in emerging economies. The challenging fact that globally distributed products must meet the requirements of each respective market needs to be taken seriously. Not without reason, standardization organizations and CABs strive for globally unified standards and certification frameworks – increased demands, increased revenues for CABs. This much is clear.

However, in times of digitalization, a fundamentally new market principle will take effect: More and more products and machines will be connected to the internet, companies will automate their processes, and new players will enter markets unexpectedly. The exponentially growing complexity of the Internet of Everything will become seemingly uncontrollable in terms of safety. Manufacturers as well as conformity assessment bodies are on the lookout for solutions.

New Safety

The central performance promise behind the business models of successful CABs concerns the assessing and guaranteeing of safety. Customers in the TIC industry are mainly located in the B2B sector. However, in the end the focus is indirectly also on the safety of the customers' customers. Institutions in the technological testing sphere make a distinction between safety and security. Safety means avoiding unacceptable risks or physical damage to systems and their components, avoiding environmental damage, and preventing malfunctions of safety-critical processes via the test objects themselves. Security concerns the prevention of criminal acts and includes any measures that prevent the unauthorized manipulation of a system, machine, or network environment. In 2027, end customers in economically developed societies will demand safety when using products and services as well as technological equipment. Manufacturers and CABs will also need to keep this central performance promise in the future, but will not thereby be rewarded with any special recognition or appreciation from their stakeholders, who will expect this as a minimum.

"All conformity assessment bodies have a common problem: the market needs to be able to trust in the reliability of the services they provide. If the market doesn't believe that such bodies are competent and reliable, then they're out of business."

Stephen Scott, Founder and CEO, Starling Trust Sciences

The area of IT security has long been viewed in a vacuum. Against the background of increasing connectivity, the dimensions of safety and security merge as virtual malfunctions can influence physical systems. From the point of view of the TIC industry, safety and security are objectifiable issues whose scope is pre-determined through standards and thresholds (and is

likewise shaped by industry and by CABs). From a users' point of view, being "safe" mainly refers to a feeling, a conviction, a highly subjective sensation. An example that helps illustrate this is the fact that the market for various supplementary safety components for home protection is booming. Users install double locks, alarm systems, surveillance cameras, or smoke, fire, and carbon monoxide alarms (and the corresponding insurance policies) to protect themselves while primarily serving one purpose: to enhance their feeling of safety.¹

This feeling is highly individual and leads to a wide variety of demands for products and solutions; in the digital sphere, many users have come to rely on ratings systems and social media reviews, but are unsettled by fake news, social bots, and data-driven manipulation – everyone involved already knows that the supposed opinion of a possibly fake community cannot replace any objective and qualified statement ... which in turn cannot replace a personal feeling of safety. Safety in a cyber-physical environment will raise new challenges for industry and for the TIC sector. Still, these new dimensions of danger resulting from the digital layers of tomorrow's world will hardly be tangible for most users, and will result in a new dimension of safety needs. Thus this study introduces a third dimension of safety for the world of 2027: prevoidance.

Parallel to the universally attested increase in the need for safety, novel technologies enable companies to paint a precise picture of the needs, emotions, and soon also the thoughts, of their customers. Customers require an individual, scalable, and adaptive design for these safety levels: security-by-design is the end objective when the focus is on safety, security, data protection and security, trust, combinability, capacity for integration, interoperability, resilience, and autonomous adaptation. In the future, custom security-by-design solutions will be a credible market emerging between industry, commerce, and the TIC

¹ A differentiated segmentation of users' safety needs in smart homes and smart buildings can be found 2b AHEAD's trend study "The Safe Building of the Future," which can be found on the internet under: <http://www.future.consulting/research/studies/trend-study/article/the-safe-building-of-the-future/>

industry on the one side, and consumers on the other.

"Digital natives have a different understanding of IT security compared to older generations. Older people are aware of the issue, but shy away from accepting this complexity in cybersecurity, as well as the rapid speed of development. They are simply afraid. For younger people, IT security is much less of a problem. They know about the risks and deal with protection mechanisms in a much more progressive way, and are generally sensitized to tackling and implementing security topics."

Dirk Backofen, Head of Portfolio Management, Engineering and Operations, Telekom Security

Worst Case

In connection with the Internet of Things / Internet of Everything, safety-critical infrastructures will become increasingly networked. A topical example: the smart grids that facilitate new services, new comfort, and new business models. What sounds like paradise in terms of consumer benefit – increased transparency accurate down to the hour, ease of use, interoperability – has the potential of devastating risks for the entire system: The repeated synchronized use of atypical functions can cause temporary or even permanent damage to the entire infrastructure. At the worst, this could lead to an extensive power failure lasting days, or even to the destruction of a power grid which took decades to build. Against this background, science fiction dystopias of hacker attacks that paralyze entire societies sound only semi-fictional.

The need for a powerful counterbalance that oversees and guarantees the safety of the entire system rises proportionately as more and more devices are connected to critical infrastructure.

Data-driven business for the TIC industry

Another consequence of increased networking is that data frequently changes owners and thus can be used by providers for new business models. Here it is no longer the companies in possession of infrastructure that will be the winners – attackers entering the market with digital, data-driven business models will also have good chances. In the conformity assessment sector, competitive pressure from new providers has been comparatively low so far. The market is divided fairly neatly between competitors; the barriers to market entry are high. Without advanced testing systems and facilities, without highly competent and experienced staff as well as adequate company-wide experience, authorization through national accreditation authorities is impossible. However, digitalization will massively challenge common benchmarks. In times of exponential digitalization in all areas of life, what will change in conformity assessment?

As a result of digitalization ...

- ...new business areas for safety providers will emerge. Digital products and technological systems will continuously send operational and error data to authorized recipients. New starting points for safety monitoring will open up and are already being used.
- ... products will become individual, leading up to lot size 1, which will fundamentally challenge today's principle of testing, inspection, and certification, thus necessitating new solutions.
- ... products will become adaptive. These products will change (autonomously) throughout their usage lifetimes, thus broadening the spectrum of possible interdependencies.
- ... many digital and virtual objects will appear, raising the complexity of safety inspection to a new level.

It consequently pays to take a look at B2B2C / B2B2B constructs in which conformity assessment bodies are involved in the data stream along the entire value-added chain – even down to the scaling and monetization of end user safety. The market for suitable safety enhancing products and services will thus increase. The central drivers for this are the realtime monitoring of technical facilities as well as manufacturers who use new production and simulation procedures in which safety-relevant interdependencies are excluded from inception. Additionally, tomorrow's production and testing processes will provide products with a highly developed intelligence which even encompasses the autonomous adaptation to user needs. This means that the TIC industry will no longer only develop new testing guidelines for standard products and equipment (certified for a limited shelf life under the condition of normal use by a normal user). Instead, the industry will increasingly become oriented towards the safety of unique products or of technical facilities with lot size 1 – for which systems, processes, and persons are accredited and certified.

Against this background, established CABs will face massive challenges. There will be an increase in the pressure to develop new solutions so that industry providers will be able to defend their market position against attackers. Manufacturers will demand new answers to the safety question for their products. And these answers will increasingly be delivered by the private IT security industry. Additionally, end customers will come to play an increasingly greater role: It is they who, through the use of products, will lay the foundation for digital business models by providing access to their user data, and it is they who will play an active part in product development while at the same time demanding shorter delivery times, driven by areas where this need is already successfully covered. Providers who are authorized to evaluate customer data will be the winners in this digital race. It is not important to end customers whether this is a manufacturer, a CAB, or a third party as long as the return is worthwhile.

"Manufacturers are dictating the speed of development. Time and monetary resources can and must be adjusted in light of this development by digitalizing conformity assessment and product monitoring. Additional drivers are European harmonization, international standardization, and the complex challenge of taking IT security and data protection into consideration as a cross-sector issue when testing any product or service."

Dr. Raoul Kirmes, Head of Staff Unit II (Core Operations), DAkkS, (German National Accreditation Body)

At the same time, the TIC industry is subject to the same changes as all other industries touched by digitalization: It's core service ("certification") will move into the background. In the future, the product "trust creation" will take on a far more important role for customers along every value-added chain, taking into consideration that trust in the analog world is something fundamentally different than trust in the digital world. Many digital players have successfully taken this step in diverse industries with considerable expertise and speed, and have made analog mechanisms partly obsolete through highly scalable and customizable products. CABs that want to be successful in ten years' time need to follow an important rule of thumb: It is better to develop digital business models today – before competitors or attackers do. It is therefore a worthwhile investment to examine what objects will be certified in the future, what processes are necessary for this step, and what needs are being articulated by customers and end customers. The present study provides the most important approaches to these questions.

"In the future, trust will not primarily be created through certification, but through standardized processes that generate and ensure quality and reliability in the manufacturing process and in the provision of services. In the end, the networking of management systems such as risk management, quality management, and information security will be the thing that creates trust in systems and processes."

Dr. Ulrike Bohnsack, Member of the Executive Board, Standardization Division, and Director, DIN KonRat, DIN – Deutsches Institut für Normung e.V.

"Who is creating trust? As an industry representative, I would love to say that the job is ours alone. Not at all! We need to be honest about this, and it makes sense to bring all the relevant players on board. This is not a question of an industry, and certainly not of a company or one of politics – we need to bring all stakeholders and certification bodies together at one table with the corresponding testing experts."

Dr. Eckhard Hempel, Director Strategy Development, Siemens Health-care GmbH & Principal Healthcare Consulting, Siemens AG

Framework: Norms and standards

It's the trilemma of the conflicting speeds: Technological development is making progress increasingly fast, and innovation and product development cycles are becoming progressively shorter. National and international standardization organizations need longer for the formulation of new norms and standards than manufacturers need to introduce new solutions onto the market – and legislation lags behind even more, thus slowing progress, because the lack of standards hinders industry's development work. The evolution of autonomous cars is a particularly vivid example of this trilemma.

"It is becoming increasingly impossible for legislators to regulatively capture societal and technological phenomena in time."

Dr. Elisabeth Stampfl-Blaha, Vice President, International Organisation for Standardization (ISO)

"We are working on shorter development times for standards. In terms of purely national standards, we have currently achieved a moderate preparation time of 27 months. Our objective is to reduce this to 18 months, including full consensus building and at a high quality. Here digitalization takes up a lot of room as it allows for completely new forms of collaboration between players."

Dr. Ulrike Bohnsack, Member of the Executive Board, Standardization Division, and Director, DIN KonRat, DIN – Deutsches Institut für Normung e.V.

The rapidly advancing digitalization of processes will significantly accelerate the establishment of norms and standards. However, the speed of industrial developments is many times faster still, and there is yet no end in sight in the face of more and more new players and continuously swelling production and computing capacities. One important driver for this are market developments. Let's stay with the example of autonomous driving: Attackers such as Alphabet (Waymo) or Tesla Motors have overtaken the automobile market from outside of its defined boundaries – without waiting for any regulation or standardization. Long before any legislation was passed or any liability clearly established through international standards, the first vehicles with partially autonomous systems were already on the road. Large, traditional manufacturers wanted to keep up, and postulated that they would be liable for any losses in the event of an accident undoubtedly caused by the autopilot system. Legislators and standardization organizations must simply react more efficiently to such new developments to avoid massively losing significance as the formulation of norms and standards becomes increasingly informal and open source. The tendency to release utility models and construction plans in order to reach industry standards more quickly is a step in this direction: Players in the industry and the TIC sector work together to establish standards that are immediately adopted by the market – long before an official norm exists.

"Existing organizations in the area of standardization – and testing – still have great room for cooperation. Their image is anything but forward-thinking – they will have to work together to change that."

Dr. Elisabeth Stampfl-Blaha, Vice President, International Organization for Standardization (ISO)

"It is obvious that every company currently has its own ecosystem – the market is very protectionist in nature. On the other hand, it can already be seen today that opening systems actually causes greater added value, such as app programming for smartphones. This results in a much greater drive for end-use applications as well. And you can also transfer this to other domains."

Dr. Daniel Schneider, Head of Department Embedded Systems Quality Assurance, Fraunhofer Institute for Experimental Software Engineering (IESE)

In the context of the TIC sector, some parts of the industry have experienced that lengthy review processes hinder innovation. Several players are currently having an impact on reducing temporal expenditures as well as testing and certification costs. The objective is once-off testing paired with general, globally valid certification – possibly with the modular and automated adjustment of the respective environment and with largely automatic recertification.

Varying development speeds result in further questions: Who will bring about safety for users and the environment if technological developments are implemented faster than standards, norms, and laws? Who translates safety into the design of technical facilities and cyber-physical systems? How can users' trust in technological solutions be strengthened if norms and standards do not yet exist? The following section will answer these questions – and will reveal the resulting business opportunities.

"The future belongs to multiple testing for manufacturers and one-stop certification through certifiers where the certificate is valid not only in a single country. In the end, the industry longs for one-stop testing and one-stop certification. Tested once and directly certified for all markets."

Heinrich Herbster, Hekatron, Head of Market Development and Member of the Executive Board





2. TEST OBJECTS

How the objects of safety testing will change in the future.

At the center of today's business models for conformity assessment bodies are products, technical facilities, systems, persons, services, or processes that are subject to assessment in dependence on the respective norms and standards. The more digitalization progresses, the more obvious it becomes to safety providers that the internet not only transforms communication and distribution channels, but directly impacts product landscapes and manufacturing processes as well. In short: Digitalization will change the entire value-added chain from purchase to production and distribution and all the way to use. Put even more succinctly: The internet will transform products.

Up until now, a successful production strategy has centered on maximum efficiency: Products are kept as standardized as possible and, at the same time, provided with limited individuality – the more the better. However, this mass customization trend of previous years has its limitations: At this stage our products have limited individuality at best. Products are more or less adapted to the customer's current needs in the production process within the boundaries defined by the provider. The future will look fundamentally different: New production

mechanisms and the real-time networking of customer data with technical facilities produce truly individualized products – products that, over time, will also adapt to changing customer needs. The future belongs to the business of unique products.

The digital revolution also means sweeping changes for the TIC sector. On the one hand, the number of possible interdependencies between each test object is increasing. And on the other, the transformation of product landscapes exemplifies how far-reaching digitalization will be for CABs and the safety system.

The central driving forces behind the transformation of product landscapes can be found in four areas:

- A.** Products and technical facilities will become digital.
- B.** Products and technical facilities will become individualized, leading to lot size 1.
- C.** Products and technical facilities will become individualized and can change to fit the present situation: They will become adaptive.
- D.** New test objects for the TIC industry.

A. Digital products and technical facilities

The progress of computer technology allows increasingly powerful and, at the same time, increasingly smaller computer chips at no additional costs. Providers from across industries will take advantage of this situation to equip their products with sensors and connect them to the internet. Around the year 2025, the number of "intelligent" devices will thus exceed one billion for the first time; be it intelligent door locks, fitness wrist bands, or self-driving cars. Each of these devices will contribute to an improvement of the user's situation by collecting data, intelligently evaluating it, and translating it into recommendations for an optimization of the user's everyday life, state of health, or financial situation. At the same time, connection to the internet will potentially open the door to cyberattacks. In 2027, devices will additionally be equipped with increased intelligence and will exchange data more autonomously – instead of recommending a solution that optimizes, devices will conduct the optimization process automatically. This will give rise to complex interdependencies no longer transparent to human observers.

"On the subject of Industry 4.0, everyone agrees that it will come and that people need to act – but no one really knows what to do. You can ask about this a thousand times, only to be surprised that people cannot immediately tell you what their main problems and desired applications are. Instead, you have to discover this yourself through laborious trial and error. Here we're talking about process data from production that you can monitor in real time: Where is something going wrong, where is everything in the green ... but historically also in the sense of, for example, the parts tracking needed for a complete product description. This would be something that will become very interesting in the certification process as this is exactly the kind of data you need to say: 'Yes, everything is going all right; in terms of parameters, the production process was in good shape the whole time' – or precisely the opposite."

Peter Oltmanns, Director and CTO, Tomorrow Labs

Analog products only needed to be secure in the analog world. However, digital products also require security in the digital world. From the perspective of testing institutes, a new digital level will emerge in this process. In addition to physical safety requirements, there will be those that will arise from the ongoing exchange of data between devices, their users and manufacturers, and external providers, as well as those resulting from the global interconnection of devices, systems, and infrastructure.

Apart from the security of the data stream (IT security), several challenges emerge for safety providers. It is not only the prevention of unauthorized access into the IT environment, but also the manipulation of recorded, sent, and decentrally stored data that will increasingly come into the focus of certification bodies. Data that, for example, is collected with a fitness tracker and sent to the user's insurance provider in order to adapt the insurance policy to their current situation, could potentially lead to a termination of the insurance contract in the event of unnoticed and unauthorized manipulation – and this is a harmless example. Such scenarios, and even more their prevention, will number among the demands naturally placed on product safety in the future.

The good news for safety providers is that all products and equipment will require an enhanced safety evaluation, which is why the demand for product certification increases in parallel with the number of devices. The new challenge: As soon as all products are connected to the internet, it will also be necessary to consider the safety of the entire system and of other products, as well as the synergy effect that arises through interconnection itself. Collective intelligence as well as the complexity of a system that is no longer comprehensible will require fundamentally new solutions. The risk: This is where a new and broad field for digital providers will emerge who offer solutions for software-based safety updates with a high degree of digital expertise. Here the conventional and largely manual test principle of one-off testing for individual products falls short.

"The word 'adaptive' in this context has a very interesting connotation because in the security software market there is at least one critical variable we'll never control: what the attackers are going to do the day after a security product launch. They'll will have all the products from the different vendors at their disposal to test whether their malware creations are detected. Attackers will modify their malware until no security product detects it, releasing only those able to evade the combined defenses. At this moment, probably there are more people working to defeat security defenses than those working in the security labs: Malware is a business model that reaps billions for cybercriminals (ransomware raked in \$1 Billion in 2016), and nowadays has the support of some large entities; governments and certain three-letter security agencies with huge resources. So, any security solution must include the capability to adapt in real time to this context – combined security approaches like that provided by Panda's Adaptive Defense are therefore essential, because this ensures global system trustability through the continuous monitoring of all applications, thus providing present protection against current and future attack methodologies."

Iñaki Urzay, Chief Security Strategist, Panda Security

B. Individualized products and technical facilities → lot size 1

In 2027, consumers will continuously and consciously leave a digital trace of their private and professional lives through all of these connected devices. Data-driven providers – both those consciously and unconsciously authorized by the consumer – will constantly collect data about the health status, shopping behavior, whereabouts, and emotions of users, which they then use to form a precise picture of their individual needs. This will enable providers to meet customer needs with intelligent product development, and products themselves will become intelligent (to a limited extent). These developments began in the service sector with ever-decreasing module sizes for insurances policies or telephone charges and reached the world of material goods in the mid 2010s. Users have become

accustomed to these individualized solutions and will expect this for every kind of product in 2027. The widespread individualization of products is thus another driver behind the transformation of product environments. Individual components will to a large extent also become scalable and geographically detached from a complicated production infrastructure, and can in the long run even be manufactured by proactive users themselves, in large part thanks to 3D printing technology. In 2027, this effect will have pervaded most of the clothing industry³, living environments, and the medical industry⁴, where providers such as iCarbonX develop personalized, genetically optimized health foods for sale to private individuals.

"It would of course be desirable that, in the future, every customer receives their personal dream car. Similarly, the production process has to become very flexible and adaptive and at the same time, safety engineering must also become flexible. In order to achieve this it is necessary to make products modular in the planning phase to an extent that every variant can easily be represented at the level of safety engineering. So if I only exchange one sensor and then activate another feature, it will be represented 100% automatically in my models in a modular way, and I will see the effects in the entire safety argument, in the entire safety cage. In this context, traditional techniques of monolithic analysis, Excel sheets, and here and there a couple textual descriptions are of limited usefulness. This high degree of variability makes scalability impossible. You need all relevant models, from danger and risk analyses to safety requirements and the safety concept, from the argumentation, the integrated measures, and the actual system architecture down to all the artifacts, software, and systems engineering – and ideally in an ecosystem, in a tool environment, in a continuous tool chain with something of a built-in principle of transparent cause and effect: If you change one variable and produce a variant, you will automatically see the impact of all this."

Dr. Daniel Schneider, Abteilungsleiter Embedded Systems Quality Assurance, Fraunhofer-Institut für Experimentelles Software Engineering (IESE)

³ "The future of the textile industry has been extensively described in 2b AHEAD's trend study "Textile Customers 2026" and can be found on the internet under [http://www.zukunft.business/forschung/studien/trendstudie/trendstudie-zukunft-der-textilbranche/\(available in German\)](http://www.zukunft.business/forschung/studien/trendstudie/trendstudie-zukunft-der-textilbranche/(available%20in%20German))], living environments, and the medical industry.

⁴ In 2015, the 2b AHEAD ThinkTank published a pioneering trend study about personalized medicine which is available online at <http://www.future.consulting/research/studies/trend-study/article/the-personalized-medicine-of-the-future/>] where providers such as iCarbonX develop personalized, genetically optimized health foods for sale to private individuals.

The question of consumer safety will become increasingly important considering the tension between consumer demands and the product ranges of market-driven players – not least as a quality pledge and point of differentiation for manufacturers. Manufacturers will primarily be interested in satisfying their customers – especially before their competitors do. The new quality in terms of the demand for safety will increase the tension at the interface between manufacturers and certification companies. Those who can guarantee safety and individualization without slowing down processes or increasing costs will thus gain a massive competitive advantage.

While, in the "old world," the most efficient form of conformity assessment and the smallest possible unit was the type certification of product lines, the new product principle demands more. One possible solution here is to allow product individualization only on a level of design irrelevant to safety, or to create at most one product variant or a small number of variants for each target group persona. Thus the effort would be reduced to covering a manageable number of entities.

In terms of the certification of persons as well, more will be required than a standardized assessment of university degrees and knowledge that can be represented in a digital format. Highly individual and barely objectifiable factors such as creativity, interpretative taste, and problem solving abilities will become the focus of personal certification. New technological solutions such as Precire (see Use Case above) can aid in the automated analysis of the character and psychological profile of a person.

The rapid rate of product development will make it necessary for the TIC industry to optimize their own processes in order to achieve individualization with the aim of addressing each user's personal perception of safety. Conformity assessment bodies that are able keep up with the speed of production will be the winners of 2027's digitalized market. Thus the customer demand for individualized products will drive innovation among

manufacturing companies which, in turn, pass the pressure on to CABs.

In some sense, the CAB market has been essentially divided for a long time as there has been a need for certifiers to have highly specialized equipment and specific competencies. For the first time in recent memory, the pressure between competitors is rising again. Unlike in past times, market distribution here no longer aims for extensive competencies in distinct industries. In the future, it will be a question of speed and of enabling TIC customers to offer their customers individualized products – quickly and safely.

C Adaptive products and technical facilities

The next stage of product development goes a step beyond individuality. In 2027, manufacturers will have switched over to making their products and services adaptive for some time: Products and services are not only individualized, but can also be adapted to changing usage situations after purchase. As customers experience this more and more across industries, the pressure on companies to be able to satisfy this need also increases.

To begin with, all requirements that apply to individual products are also valid for the conformity assessment of these adaptive products – however, completely new requirements will be placed on conformity assessment thanks to the flexibility of products. The possibility of post-purchase product adaptation is not only possible on the part of the manufacturer, but also by the customer. This raises the question of responsibility, trust, and safety to a new dimension.

Even before an adaptive product has been bought, one particular challenge needs to be taken into consideration: It is not only various modules and the possibilities opened up by individualization that need to be integrated into the process of conformity assessment: In the future, it will be necessary to assess the norm conformity of all interdependencies of all

modules that could later be changed or purchased as add-ons. Finally, the result (especially in the area of connected products) is more than the sum of its parts.

"In the context of IT security, we already use machine learning for various products, for web security, and for SOC / SIEM solutions. We know when and where certain attackers will possibly want to spread phishing messages or ransomware. We are then able to initiate countermeasures before any damage is caused. 'Made in Germany' will establish itself in the IT security sector as well – our customers will want their security solutions hosted in Germany under German law."

Dirk Backofen, Head of Portfolio Management, Engineering and Operations, Telekom Security

The more far-reaching result of adaptive products and digital market mechanisms is nothing less than a disruption of the entire TIC business model. While, in the old world, the main focus of CABs was on testing products, processes, and people, adaptive product environments will lead to completely new safety requirements. According to the central mechanism of digitalization – the separation of material products from their immaterial performance – the significance of official quality labels for generating consumer trust in a given product will increasingly sever itself from the safety promise. Due to the vastly differing individual safety needs of consumers, all market stakeholders need to ask how they can sustainably guarantee customer trust. Providers who are the first to make trust quantifiable – and, with their business models, usable – on a large scale through digital technologies will be the leaders in the field.

D. New certification objects

Digitalization will not only change test objects; new ones will also emerge. As early as the mid 2010s, immaterial systems such as cloud or fog computing came to the attention of CABs as, with their market launch, companies took a first step towards opening up safety-relevant areas of plants, machines, and com-

panies to the internet. In the future, material goods will increasingly be replaced by immaterial or digital solutions across industries. Thus physical house keys that fit the door lock of a smart home will no longer be produced in the future – key apps such as kiwi.ki will take over this function, and require a completely different test principle compared to products from the analog world. The increased spread of digital business models and sharing platforms, e.g., Uber or AirBnb, also has the effect that CABs will soon be confronted with new business segments. These platforms also have the effect that the material goods offered through them see increased use. In terms of owners and users, this will consequently lead to a rising demand for the mutual assurance that both digital products and material ones comply with certain safety standards. Conversely, new (adaptive) quality labels in this field can increase the acceptance of those labels by consumers, an acceptance that has partly been lost among traditional usage principles.

"People don't trust the establishment anymore, so there's a huge opportunity for tech startups to come in and create a new relationship with consumers who have lost faith in traditional institutions. One powerful example is Airbnb, which has come into the market with a platform that creates trust among complete strangers...!"

Stephen Scott, Founder and CEO, Starling Trust Sciences

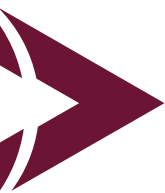
Other new test objects will develop in future industries such as algorithm-driven commerce and the autonomous dealings of digital assistance systems. Algorithms for the execution of simple subtasks in all sorts of digital application environments, and even entirely autonomous companies such as The DAO, will make a new dimension of testing principles necessary. Thus conformity assessment bodies face a new challenge as here they are not testing a real object or even a virtual concept, but something even more difficult to evaluate: the end result of complex, self-learning algorithms. Even programmers are often unable to comprehend how these complex codes function,

codes which are increasingly based on artificial intelligence (AI). The integration of such algorithms into products or product environments holds a potential safety risk in the event of unauthorized access into the system – which is why the demand for safety certification or for the real-time rectification of adverse events will arise.

"In 10 years' time, the internet will be separated into two parts. One is the unsafe internet where everything without protection mechanisms can be found. The safe internet, on the other hand, will be managed and kept safe by large security and telecommunication operators worldwide. Active firewalls, filters and APT protection mechanisms will mean that customers need not fear any viruses, malware, or threats of any kind."

Dirk Backofen, Leiter Portfoliomanagement, Engineering und Operations, Telekom Security





3. PROCESSES AND BUSINESS MODELS OF THE TIC INDUSTRY

How the industry's processes will benefit from digital technologies, and what new business models will emerge.

So far, the TIC industry's principal task has been the certification of standardized products. It developed a certification process for standard products that could then be used in many situations. The greatest achievement and strength of CABs has been their ability to repeatedly apply this process in a transparent and comprehensibly standardized way. Completely new product dimensions and products are emerging in the context of digitalization; products are becoming digital, individual, and adaptive, and new types are also entering the market. This requires new testing processes – and consequently new products – from CABs, bringing challenges and opportunities for established players. Companies that sense a new market in these products and offer new solutions for test processes here will be more successful.

It is not only the changes on a product level and new customer demands – B2B as well as B2B2C – that require an adjustment of the testing process on the part of conformity assessment bodies. New technological possibilities, as well as digitalization and technologization on the part of manufacturers, are also leading the TIC industry to change its processes in terms of the following future questions: Who will conduct the certification process, the inspection, the test? How is the process

changing exactly? At which point – from the development phase to the end of the product life cycle – will the test be carried out? And what added value can CABs offer their customers in addition to their core services?

Use of technology in the testing process

In the past, it has predominately been human certifiers and auditors who have conducted the assessment and evaluation of products and technical facilities. In recent years, however, the testing process has become increasingly technology-based. More and more technology is being used in a range of processes: Starting with the main inspection of motor vehicles which is, to a great extent, performed with the aid of assessment devices and sensor data, and leading all the way to the use of sensors to test production.

This development is being driven by the manufacturers themselves: They optimize their own production procedures through the latest technologies. They digitalize processes, use robotics and intelligent production machines, connect these systems, and thus become increasingly digital. Manufacturers target their efforts primarily on the optimization of their own value-added

chains, structure their processes from the standpoint of cost efficiency, and address their customers' need for fast service. Yesterday's outsourcing into low-wage countries is tomorrow's complete substitution of human labor through autonomous production machines and algorithms.

"In a completely digitalized and optimized world it would truly be visionary for certification to be carried out digitally and automatically. Machines will be so well optimized and processes so highly digitalized that equipment or even the production process could be certified through a digital twin. The final certification step will be carried out locally, but much faster than before. And the digital twin itself will automatically produce the complete documentation."

Ulli Klenk, Head of Additive Manufacturing Product Management & Sales, Siemens AG

Over the course of digitalizing their own processes, the trust of manufacturers in technological solutions has grown. They know that machines are more precise than humans, and have learned to trust the judgment of machines. They have experienced that the results generated with the support of technology are cheaper, available more quickly, and ultimately better. From a manufacturer's point of view, safety and safety inspection are not the driving forces behind the digitalization of the production process, but are factored in during a second step. From their own intelligent and automated production environments, manufacturers are now used to employing systems, processes, sensors, and analytical tools in order to test and guarantee the quality and safety of their products. They also expect the same openness with regard to data-driven systems from those who test their products for operational safety and hand out seals of certification. This increases the pressure on conformity assessment bodies to offer technology-driven testing processes.

"Everything that can be digitally simplified through tools, software, and also through other processes and process improvements will appear sooner or later. We are nowhere near the end of the story."

Dr. Eckhard Hempel, Director Strategy Development, Siemens Healthcare GmbH & Principal Healthcare Consulting, Siemens AG

Here the automation of individual process-related steps by CABs is only the first step towards a technology-assisted testing process. Thus simple process steps such as reporting, controlling, and all documentation of the testing process will not only be digitalized by 2027, but will also be automated. In the future, CABs will provide manufacturers with tools – e.g., according to the App Store principle – that allow human certifiers and auditors to digitally exchange information with manufacturers, no longer forced to send a representative to a physical site. This is driven by efficiency enhancement, and thus by savings in time and money, on the part of conformity assessment bodies and manufacturers.

A broader dimension of a technology-assisted testing process is the use of simulations that are based on intelligent algorithms and artificial intelligence. These test safety even before the production process instead of merely carrying out the test post-production with a cumbersome battery of testing processes. For CABs, simulation means the implementation of cross-sector, interference-free testing that is integrated into the product development process at an early stage. The arguments for simulation are obvious: Manufacturers save a lot of money throughout the entire certification process, and the quality of the safety test improves at the same time. Last but not least, the simulation of all conceivable cases is possible. Simulation raises the safety of a product to a higher plane. In reality, however, simulation can only be conducted at immense costs.

"Without any question, the use of simulations will increase significantly in the future. In the beginning it will not be possible for simulation to replace the entire testing process – if this is even possible at all. However, risk assessment through simulation will definitely gain relevance in the near future."

Dr. Raoul Kirmes, Head of Staff Unit II (Core Operations), DAkkS, (German National Accreditation Body)

By 2022, however, only part of the testing process will be covered by simulations. Although safety-critical facets of a product can be identified through simulations, by 2022 testing itself will still be conducted by human agents. As the performance of computer systems increases, the possibilities of simulation will have improved massively by 2027 so that, in this way, larger and larger numbers of possible scenarios can be evaluated quickly and cost-efficiently. Software testing through simulations, such as for example formal proof verification, can thus ensure an almost 100 % coverage.

"We are not yet ready to say today that computer simulations can cover everything that is tested by humans. However, these simulations can prepare tests and cover some parts of this spectrum. In the future, software will be able to provide a 100 % coverage."

Christoph Jentzsch, Founder and CTO, Slock.it

Artificial intelligence in the testing process

The driver and facilitator for the expanded use of software in the testing process is the continuously increasing performance power of AI – a development that, by 2027, will dramatically shift the foundations of conformity assessment. AI and the associated evaluation of long data sets during the testing process will make it possible to gain completely new insights into products and to identify potential weak points or safety risks. In a few years' time, deep learning algorithms will be able to simulate scenarios literally unthinkable to users. The serial connection of neural networks increases the potential of the consequences

and interdependencies which are possible to simulate. Faster than real-time and in a non-destructive, non-invasive way, AI will create scenarios and test them with regard to safety-relevant issues. The true potential of artificial intelligence will particularly become apparent in combination with different products, processes, and application environments.

AI has long had top priority for the world's major IT corporations. The actual momentum of this development arises from self-learning algorithms: The structural principle that individual knowledge gains are universally available for further development opens up completely new dimensions of speed. This is Tesla's strategy in implementing their self-driving cars. This is the strategy of Google Deep Mind in the development of AlphaGo. This is the strategy that Sentient follows and with which they facilitated their automated predictive day trading. Such examples have already shown that it is possible to transfer empirical knowledge of these systems between industries, which will consequentially lead to a significant progress in machine learning over the next few years.

The intelligence of computers will not remain restricted to certain areas in the future. Even in our lifetime, we will most likely see that computers will achieve the same general intelligence as humans. This so-called human-level machine intelligence will be considered accomplished as soon as machines and computer programs can perform approx. 80 % of human jobs equally well as the average person.

"Users still need to learn to handle intelligent algorithms – just as with any change or new technology."

Prof. Michael Feindt, Founder and Chief Scientific Advisor, Blue Yonder

However, even in 2027 certifiers or auditors will not be fully replaced by AI. Testing by an actual person will remain in place where the focus is not on pattern recognition, but on tasks that require nonstandardized experience and situational creativity. It will become more obvious to some TIC customers where careful testing through AI does not offer the desired

objectifiable safety. This is where experienced certifiers come into play – with their skills, their instincts, their personal credibility. Conformity assessment bodies can offer this personal testing as a special service in the future.

This will mean an extreme increase in job complexity for human certifiers and auditors, as well as a transformation of their professional profile. On the one hand, they will only carry out specialized tasks that cannot be accomplished by machines. On the other hand, they will need to perform a growing number of activities that emerge at the interface to new technologies and artificial intelligence. The collaboration between humans and machines will thus increase the quality of the testing process. It is in fact possible to say that the testing process in 2027 will be carried out by a human / machine organism.

"Big data and intelligent systems generate great added value if understood holistically, without taking into consideration departmental boundaries. Because this is the heart of the matter: connecting and comprehensively optimizing data from different areas. Firstly, this requires more openness on behalf of individual departments. And secondly, it also calls for a rethinking processes at management level and in specialized departments and IT, as well as in terms of the roles of each staff member."

Prof. Michael Feindt, Founder and Chief Scientific Advisor, Blue Yonder

The search for suitable staff

Conformity assessment bodies thus enter into competition with other companies from different industries for IT-competent staff. Be it the health, mobility, telecommunications, or automobile industry – all sectors will increasingly use technology and seek job candidates who can actually use this technology. Due to their highly specialized requirements, CABs will be hit particularly hard by the shortage of skilled labor.

Another important new core competence of CABs will thus be a successful employer branding strategy in order to win the race for talented staff.⁵

Although digitalization will increase the pressure on the TIC industry in terms of staff recruitment, it will reduce it in other places. As "simple" tasks such as documentation or process controlling become automated, CABs will most importantly need highly specialized personnel – but not as many as before. Without an automation of processes and simulation, many conformity assessment bodies will no longer be able to offer their services thanks to a lack of human resources. Those who are able to promote the digitalization both of their own processes and of the recruitment process over the next few years will be the winners.

Changes in the auditing process

In the coming ten years, technology will take decisive steps from being a powerful aid to becoming an active and influential shaper of the testing process. The demands placed on tomorrow's testing process – and thus also on future business models – will subsequently change. Consequences for the TIC industry can hardly be overestimated.

Today, the conformity assessment of test objects occurs primarily post-development, even though in some industries (and especially in medicine) the interface between the TIC industry and manufacturers is very closely connected even in the conception and development phases. However, it is far more common that CABs, in coordination with manufacturers and standardization institutes, develop test schemes as soon as a prototype – or even the finished product – has been created, waiting until this point before initiating tests and assessments.

⁵ The relatively unknown manufacturer of smartphone modules Changying Precision Technology Company Ltd. runs production round the clock at its almost entirely automated plant in Dongguan, China. A staff of only three checks at selected points whether all machines are still operating within acceptable limits – before processes became automated, the company employed 650 workers. Since then, the error rate has been reduced from roughly 25% down to 5%, and productivity has nearly tripled. China is heading for a demographic crisis; the extent of this crisis is hardly conceivable to politicians from other countries and industries. A total of 200 million of China's inhabitants are more than 60 years old and will soon leave the labor market. Many other manufacturers such as Foxconn, Siemens, GE, or Tesla have announced their plans to forego human staff as far as possible in the coming years, which shows that this is only the beginning of automated production.

This will inevitably change once manufacturers take steps towards adaptivity. They will then give up the linear progression of development – marketing – sales – services; correspondingly, there can no longer be a fixed moment from which conformity assessment bodies could start their work. They will need to react to the entire process, and data transfer must begin much earlier, thus as early as the development phase. This development will especially be driven by novel forms of production such as additive layer manufacturing or 3D printing technology. In the future even more than today, the CAD file especially will be assessed with regard to standards before any real manufacturing step has been performed or any material used.

For CABs this means that test plans can be prepared before the actual physical product is available for testing – should this still be necessary. Thus certifiers and manufacturers will have the advantage that individual requirements or construction plans can be taken into consideration by certifiers more optimally as test schemes will have been defined beforehand. In order to better adapt to B2B customer demands, CABs will make test plans in greater detail and less rigidly in the future. They will be more adaptable by nature. And they will also mainly be developed through AI-supported processes that apply the necessary processes to the test scheme.

Testing during production

Another dimension of this earlier integration of CABs into the development process will be that products can even be tested during production. Manufacturers will pass on production data to the assessment body and will naturally expect added value in return. This added value can be found on several levels. On the one hand, it speaks for itself that conformity assessment bodies will optimize their own processes with the data available – obviously with regard to testing schemes, but also in terms of simply increasing efficiency during processing. However,

even during the production process, information about where manufacturers should make modifications in this early stage can thereby be provided automatically. Smart analytics thus help manufacturers to preventatively eliminate potential problems in the production process or during later use.

Post-production testing

Today, testing a product after its production – but before it is sold – is common practice in many areas. Products are manufactured, a test scheme is developed, and testing is performed. Then, the product is sold, and after a few years the product gets recertified as needed.

In the future, conformity assessment bodies will not only use prototypes or individual serial products in order to develop a test scheme. There will be a continuous flow of data through digital interfaces between products and users as well as between technical facilities. In the future, CABs will use this data to establish a test scheme for the iterative, potentially endless testing of a product – or for other products. Thus digital products will produce and collect data during customer use which CABs can then use to optimize their own processes. In this way they will be able to offer manufacturers adaptive test schemes.

Finally, users will produce an enormous amount of data by using products. Real added value will emerge when CABs can collect data that the manufacturer does not have or cannot compile at the same quality. Conformity assessment bodies will be able to guarantee independent product testing during service and will perform ongoing monitoring on behalf of the manufacturer with the help of real-time data. This, in turn, will provide the manufacturer with coverage against suppliers and their quality deficiencies that occur over time. Together with insurance providers, CABs will be able to document the behavior of products in everyday life in order to effectively prevent compensation claims.

"Growing autonomy, learning algorithms, and more intelligent systems will lead to new challenges in terms of providing a guarantee for certain properties that are important for safety. One idea is a virtual safety cage. I cannot make any precise statement about the development time, on how a system will behave during its life cycle. It learns and has a neural network, but I guarantee certain limiting properties through the safety cage. I go a different way in my approach and restrict the degree of freedom in terms of adaptivity. The different variants that my subsystem can finally take on are all predefined in terms of the development time. Either services A and B are present with certain properties and then the subsystem can generate a service of its own with corresponding properties, or services A, D, and G are present, and so on. And each of these configurations would have a conditional certificate that defines which services can be delivered with which properties based on existing services in the environment. This is basically a shifting of the conditional certificate which can be pre-analyzed as early as the development phase. Real emergent intelligence isn't a feature here."

Dr. Daniel Schneider, Head of Department Embedded Systems Quality Assurance, Fraunhofer Institute for Experimental Software Engineering (IESE)

as testing products, technical facilities, or processes at point X is no longer sufficient if these objects change during the course of their life cycle. In the future, there will be providers who will occupy precisely this niche. This could be the manufacturers themselves, who continue safety inspection even during consumer use, but this could also be carried out by digital trust agents. In the final analysis, customers are largely concerned with a stable trust relationship to their provider; those who are able to model and to monetize this relationship will gain user trust.

"On the way to adaptive certification, the participants of the domain need to come to many agreements – it won't work without these. Everyone must agree on a model, a concept, and an idea, exploit it with certain guidelines, or define it with certain norms so that everyone adheres to it. This is generally something that will become more and more important, especially in the area of open systems. Not only in terms of safety, but certainly also with regard to functionality itself, to interoperability."

Dr. Daniel Schneider, Head of Department Embedded Systems Quality Assurance, Fraunhofer Institute for Experimental Software Engineering (IESE)

Conformity assessment does not end after testing

The traditional recertification of products and equipment will become predominately automated in the future – also in areas where this is not required by law. If CABs save time and money through the automation of processes, they will be able offer their customers greater safety at the same price through more frequent test cycles. This will make it an attractive option for TIC customers to pass this additional service on to their end customers: safety during operation as a cooperation model between manufacturers and CABs.

With regard to adaptive products that change during service life, classic conformity assessment has its limits

These niches will especially appear in industries with a high innovation rate. The need for conformity assessment in, for example, the smart home sector is enormous as numerous providers who want to digitalize analog households with new solutions are pushing their way into the market. The simultaneous and rapid development of technologies and technology-based products has the effect that safety certificates are only able to represent the state-of-the-art for a short period of time. Manufacturers often perceive the need for safety inspection as a hindrance to innovation which wastes time and diametrically opposes market demand. This is where intermediaries in the future will offer solutions that satisfy customer needs as well as the high demands placed on safety through independent third parties.

It is decisive for CABs to differentiate themselves from their competitors by transforming the testing process into one which covers the entire product life cycle. Here testing is no longer a one-off event. In this way, CABs will not only create added value for manufacturers, but also for the manufacturers' customers.

New TIC business models in 2027

The regular renewal of seals for an elevator, for a conveyor belt alone will no longer meet these demands. In the future, conformity assessment bodies will need new business models in order to create added value and to work profitably with respect to their role.

In the context of digitalization, changes in the TIC industry will be visible on two levels. First: The entire process will become increasingly automated and will be enhanced, complemented, and substituted by technology. Second: Opportunities for new operating principles will appear in parallel with emerging application environments. The following approaches for business models outline the foundation for industry stakeholders, as well as for external players who want to attack existing relationships.

Data driven round-the-clock and real-time testing

TIC companies will become the digital safety assistants for their customers. As early as the development and manufacturing phases, customers will integrate the intelligence of the provider's system into their everyday lives. End customers will also use the assistant and will benefit from continuous testing. Providers who are able to achieve this will be the security-by-design coaches of tomorrow's customers.

"A lot of data is already being collected and evaluated for internal quality assurance. This task has not yet been outsourced to external providers such as certification bodies. From a technical and conceptual point of view, this would, however, be entirely possible and desirable for the sake of transparency."

Peter Oltmanns, Director and CTO, Tomorrow Labs

Conformity assessment bodies will receive user data from manufacturers in addition to data about production processes and product properties – provided that the user has given the proper consent. This data will allow yet more detailed testing – even after the purchase and in real-time, as well as in adaptive product environments. At the same time, CABs will also be able to use this data to generate added value for third parties and to monetize this service.

In the consumer goods sector, mobile, digital, and intelligent assistance systems will find broad acceptance with customers and will replace individual functions of the TIC industry. This would of course require the manufacturers themselves and conformity assessment bodies to provide a transparent informational basis in the form of open interfaces. Some end customers will recognize added value in this layer. The providers of these applications will possibly not originate from within the TIC industry, but will be software-driven players following new market approaches.

Open and transparent testing

CABs will disclose all information about safety inspection and will also allow third parties to be involved and to supplement the process. Providers will be able to increase transparency about the testing process and its results even more when managing all the relevant data through blockchain technology. Through this, they will not only make data transparent to authorized players, but also tamper-proof, with the additional benefit of receiving automatic updates through the automated data stream. The bureaucratic burden for the TIC industry will thus be massively reduced and will also be digitally visible at all times. Seals and certificates will become more transparent and thus also increasingly trustworthy. Privacy-by-design will follow security-by-design. This represents a great opportunity for providers who are able to understand and intelligently organize data security and protection on the one hand and the individual safety needs of customers with regard to safety, security, and prevoidance on the other.

At the same time, this complete opening of the process will create interfaces to digital assistants from other providers. This service, this access to valuable information will be presented to (end) customers as worth the trade-offs involved, and will become the basis for subsequent business models – as far as data is explicitly released by the data owners themselves.

"I don't want people to think they have to give up on functionality and design and service, when talking about privacy by design. We have to get rid of that kind of mindset! That's a false dichotomy! You can have both! We need to evolve into a world without zero-sum thinking in this regard."

Dr. Ann Cavoukian, Executive Director, Ryerson University –
 Privacy and Big Data Institute

Another use case: In striving towards transparent – and simultaneously also independent – testing, the industry will aim at certificates for processes and management systems. CABs will support this through the development of "test schemes to go," making assessment devices available on loan. Measurement data will be saved in tamper-proof blockchains, after which the certifier verifies this data and issues certificates as needed.

Personalized testing

In ten years' time, it is possible that even more safety-relevant aspects of testing will be performed by human beings than today. At the same time, more and more consumers will distrust exclusively human recommendations, and thus also the judgement of a human certifier who fails to utilize modern technological aids.

However, even against the background of this intensive development towards digital products, free services, and automated processes, there will also be ongoing justification for people-based services. In ten years' time, there will still be customer segments that trust human certifiers and auditors more than mechanical alternatives, perceiving them as

authorities who create identity. It will make no difference which actual part of the services will be carried out by a human agent. Conformity assessment bodies will position individual persons as trusted contact points for analog customers, using them especially for customer communication. The time of CABs is precious – time resources that become available through automated background processes can then be used to best serve the customer beyond the expected demands for testing and certification.

Free testing

Stated radically, digitalization will lead to a "product as a service" principle in many industries. The core product or the core service will shift into the background, and instead users will pay for access or for extended services. The customer relationship will thus become severed from the possession of infrastructure, at least from a provider's perspective.

Carried over into the TIC industry, this means that CABs will give away their core services for free. In turn, they will become part of the data stream that arises during development, production, and use. They can then use this data to generate and sell knowledge for improving all the manufacturer's value-added chains. Alternatively, CABs will give manufacturers constant monitoring of technical facilities as a free service, and earn their revenues from every production unit sold. In turn, data that is generated in this way will help CABs to reduce the effort needed for recertification.

Autonomous testing: Intelligent machines and blockchain technology

Not only testing without a fee, but also testing without a certifier can become a business model in the future. Autonomous (flying) robots will soon replace some parts of testing – e.g., for pipelines or wind turbines. Special metrological hardware in combination with intelligent software will allow non-stop early detection of risks and damages, such as through ultrasound monitoring and X-rays; future-driven maintenance or predictive maintenance will be the keywords of the TIC indus-

try. 3D printing techniques will also contain monitoring mechanisms in order to guarantee safety even before the production process begins.

"Predictive maintenance on elevators or technical installations in buildings is a fact, we have that today, it exists. So we will see more and more of these things coming up. You'll receive a message on your smartphone that someone has booked a maintenance at your apartment because there is a likelihood that your dishwasher will have a problem in a week or two weeks' time. Predictive maintenance, predictive security – we are heading in that direction and we are there to some extent already. This is easier when it comes to very technical installations, and harder when it comes to complex interactions between humans. We are working on video analytics – lots of mathematics, smart algorithms – to try to predict based on past occurrences where we will have a need for future interventions as well."

Lars Franzon, Vice President und CIO, Securitas Europe

A further factor is the use of blockchain technology. The principle behind the blockchain offers more than the transparent and manipulation-free representation of information. When combining the blockchain principle with self-learning algorithms that continuously improve themselves as well as every instance of the system, you have the necessary foundation for fully autonomous testing. An intermediary who actively manages task assignment will no longer be necessary – the system operates itself. It autonomously organizes contact to production plants and products in the network, automatically organizes the necessary simulation cycles, and autonomously invoices suggestions for improvements with the customers. Blockchain systems consist entirely of programming code.

It is likely that the latter business model will not yet be implemented in ten years' time. Here the most important barrier on the way to autonomous testing is not technology, but regulation. According to our

legal system, algorithms and machines are not authorized to start businesses – and they are not criminally liable. There are only two liable persons: natural persons (human beings), and legal persons (companies and organizations). The solution can neither be found with the manufacturer, nor with CABs or users. It lies in the legal system itself: Driven by transformed demands through digitalization across industries, "electronic resources" will in future complement our legal system. However, in emerging economies that do not yet have such a strong background (regulation, TIC industry, tradition of conformity assessment), technological solutions are generally received positively. The effect "leapfrogging" refers to skipping intermediate steps that have been taken in other industries on their way to newer developments. In developing countries, blockchain technology could enter the TIC industry faster than in established environments.

Remuneration Models

The attested increase of automation in the testing process and simultaneously growing competitive pressure on the international market will lead to falling operating costs for CABs. Their customers will know this, and will either expect additional services or a significant price reduction for existing ones. Regardless of this, the pricing policy of the TIC industry will also change in terms of remuneration models; some will offer flat-rate models for recertification in the coming years. Cash back and other B2C principles will also make their way into the business – e.g., so that CABs can thereby gain access to the data resulting from the use of products and the operation of technical facilities. In individualized and adaptive product landscapes, subscription models will also be a sound approach: A certain number of individualized or adaptive products are included in the package price. Only beyond this point will the TIC customer be confronted with additional costs. Here the driver will be the continuously growing number of startups that often push for a fast market launch for their products, but do



4. CUSTOMERS & COMMUNICATION

How the TIC industry will be able to keep its performance promise of trust through modern communication.

In 2027, product environments will have fundamentally changed: products will be individual and adaptive. Through this, the processes of the TIC industry will also have adapted accordingly. New business models will evolve. As a result, the relationships between conformity assessment bodies and their customers as well as consumers will face massive change. Only with a new communication organization will CABs be able to efficiently cover the increasing complexity in the interplay between production and testing.

The requirements placed on communication with the testing company will be defined by the customer: more precisely, by the responsible person (or persons) on the customer's side. What lies behind this is a development whose reach most companies are not yet aware of today. The rapid spread and use of new technologies and devices has the effect that staff members have long transferred their private communication behavior and expectations for modern communication to their professional environment. All communication channels such as telephone, chat, email, voicemail, collaboration tools, and social networks that customers use in their private lives will

also be expected by them in the sphere of work. Additionally, the use of social networks like Facebook, Twitter, LinkedIn, Xing etc., is leading to an increasing melding of personal and professional life. These networks are being used to an even greater extent in a professional context in order to share information about service providers. Thought through to the end, this has two implications for companies. First: In 2027 communication will be individualized, which means that each customer will expect that they can use the communication channel they prefer and that their counterparts will have real-time information about their individual characteristics and contact history. This in turn means that service providers will need to offer integrated service on all communication channels. Secondly: The boundaries between B2C and B2B will become blurred and will ultimately disappear.

In the digital world, communication will increasingly be person-to-person when compared to the analog world. What sounds counterintuitive at first sight has one simple cause: Time resources for staff to personally speak with their clients will become available due to the increasingly automated processes for standard tasks. The targeted routing of the customer contact to the most

suitable team member will be an obvious necessity. Additionally, testing companies that are able to offer the same brand perception and level of service through every communication channel of their clients' preference will have an advantageous position in 2027. They can thus give customers a sense of security in knowing that their requests or problems will be processed quickly and competently. This objective presupposes that testing companies intelligently connect existing communication channels and make all existing customer information available in real time at every touch point. If a customer writes an email and a few minutes later communicates with another member of staff through online chat, the company representative needs to know the content of the email beforehand in order to avoid misunderstandings, repeat explanations, and the like. In 2027, omnichannel management will be essential for fast and intelligent communication.

Holistic communication: Omnichannel management for the TIC industry

Behind this simple statement is a complex system whose representation requires three elements. First: a powerful and adaptive IT solution. Second: the establishment of flexible corporate structures and new responsibilities. Third: a cultural change which enables staff to interpret these enormous changes in a positive light. For most companies, these prerequisites represent the greater challenge.

The use of a working omnichannel management system goes far beyond connecting new and existing communication channels. This is only the layer that is visible to the customer, the front end. The actual intelligence of the system can be found in a layer that is

invisible to the customer. Apart from the entire communication process, this layer also contains all available information, compiles it, and processes it using smart analytics. Without a doubt, the richest source of information will be the sensors that almost every device will carry in 2027. Testing companies will thus, as one example, have access to real-time production data. On the other hand, users will also transfer any data that results from the use of devices to the testing companies. The real performance of companies will lie in giving value to real-time data by evaluating and comparing it with existing data. Companies and consumers will only release their data if doing so means added value for them. This could simply be financial, i.e., testing companies pay for data, or test seals could be personalized for the customer based on the data they have shared. At company level, the added value could be carrying out the testing of a product faster, cheaper, or earlier than would be possible without any data sharing. Thus CABs will receive stronger public awareness and simultaneously greater market power through the ownership of vast amounts of data.

Redefinition of the customer interface: B2B2C as a new market

In 2027, end consumers will also be part of the ecosystem which indirectly uses the services of conformity assessment bodies. The rapid spread of sensors in all devices will make end customers both suppliers for testing companies as well as potential users. In 2027, testing companies will offer these services alongside the conformity assessment of products. For end customers, these services will be attractive at every level as the independent testing of a product, a service, or a specific issue will generate added value.

"I can well imagine that CABs will offer online services, especially regarding the safety of open systems. Systems will automatically register online if they want to play a part in any ecosystem. This is a kind of open system police force. Domain stakeholders would then come to a consensus that they want some kind of third party to monitor this, and TÜVs would certainly have the required competences. However, this kind of portal can lead to an interesting constellation between the industry and the TÜV. Some would be offended if the TÜV would not approve their product for the ecosystem. However, as a whole, the industry behind this domain will probably be most interested in a trouble-free and safe process. Thus only a neutral party or an arbitrator would make sense for the ecosystem."

Dr. Daniel Schneider, Head of Department Embedded Systems Quality Assurance, Fraunhofer Institute for Experimental Software Engineering (IESE)

"One of the big challenges for conformity assessment bodies is to communicate to their customers on three levels. First, they need to prove that they're competent. Second, that they're reliable. And, third, in addition to competence and reliability, they have to be able to assure customers of their benevolence. As a customer, I have to believe that you really care about me."

Stephen Scott, Founder and CEO, Starling Trust Sciences

"When it comes to consumers, in many situations I'd say generally individuals will trade security for convenience and price. So in other words: if they see something that is convenient and easy enough they don't care much about security, unless we are talking about for instance online banking in which security is clearly a driver or an inhibitor. We've seen this all. They're gonna trust more the brand, even though the technologies may not be that secure, more than the certification itself."

Josu Franco, Vice President Corporate Development, Panda Security

Trust as a performance promise

For end customers, the main motive for independent testing is connected to the nature of trust in institutions. Trust develops where consultation or a recommendation leads to fulfilled expectations, for example with the satisfying purchase of a product. It is irrelevant whether the consultation has been carried out by a human representative or a digital assistant. In times of progressive digitalization, the way humans gain trust in brands and providers is changing in view of the globally availability of products. In the old world, the focus was on widely spreading marketing messages and on creating attention. It is no longer enough to simply advertise products as the number of potential channels continues to increase exponentially. Instead, the question is appreciation; providers must credibly communicate that they can understand their customers' needs, take them seriously, and can competently satisfy them. It is no longer simply the pure size of a company or the number of seemingly satisfied users that will promise further potential customers.

In the digital age, new players will replace familiar faces. Rapidly growing user numbers for digital platforms like Airbnb, Uber, SocietyOne, or BlaBlaCar confirm this. In contrast to established brands, platform-based companies can be found in the same world as their users can (or want to) be found: in the digital world. Users trust that their expectations are better understood and fulfilled by young digital companies than by established providers. The more frequent this assumption is confirmed through the use of platforms and the more often customer expectations are fulfilled, the more stable trust becomes.

This transformation of trust through digitalization creates unknown territory in some places. Everywhere where dealing with the safety of products, there is need for an authority in the digital world who has the competency to assess safety. To be more precise: Customers accept recommendations for hotels in cities

they do not know without question all the time, and un-selfconsciously use Uber to get from A to B. However, if the same user is looking for the safest bike helmet for their child, they will seek an authority that guarantees the safety of the helmet. Here the digital availability of this authority is a given. Subsequently, testing companies that can gain and keep the trust of end customers in safety-critical areas through corresponding digital products will be those with an advantage in 2027.

"A good example of that, I think, is found in looking at companies like Uber. The government regulates the taxi companies and certifies that a taxi company is safe, reliable, and competent, that they care about their customers and provide a reliable service. If you get on this taxi, you'll be safe. Such is the aim. But Uber doesn't have to submit to that same certification process. So they shouldn't be allowed in the market, some might argue. And Uber responds to this by saying: 'Well, hold on, so yes, the taxi companies that are certified by the government have a government certificate, but look at how many problems there are in the taxi industry. There's crime, there's theft, there's filthy cars, there's unscrupulous drivers. So I am not sure that your system is working very well at all. My system, by contrast, is a system where passengers rate the drivers. So new passengers come in and they know whether or not a driver has been well rated in the past by other passengers. Any drivers that get below a certain level are kicked out of Uber's system. So we actually have a much better system.' And, as we all know, Uber operates quite successfully in doing that."

Stephen Scott, Founder and CEO, Starling Trust Sciences

Digitalization of trust

In 2027, customers' digital assistance systems will integrate applications from which the user expects individualized and situational information. Today's certificates are scarcely suitable for meeting these requirements as they are not easily manageable and are not available in a transparent format – and certainly not in an individual or situational one. In the future, these certificates will be replaced by those products that connect the services from CABs with the customer interfaces – it is not yet clear who will fill this gap. Just

as in other areas, such as insurance products or smart homes, customers or their assistants will generally assign the role of the digital risk or safety manager on their displays only once. In 2027, companies who can occupy this position and thus secure the interface to the customer and their data will have a clear advantage.

By 2027, companies across industries will be equipped with digital assistance systems that utilize advanced AI. This will have the effect that there will be humans on the manufacturers' staff who trust their digital assistance systems more than they trust other human beings. They will expect testing companies to use artificial intelligence in the testing process. In turn, manufacturers will inform their customers that testing has been performed through technology and not by a human. Whether the product was tested by a human or by a machine will, in 2027, be decisive for the end customer's purchase.

The more people delegate all (or some of) their decisions to digital assistance systems, the more important the question about data dissemination by third parties becomes. There will be customer segments in the future that expect a tiered adjustment of the data they have shared; the more data they release, the greater the degree of individualization, and thus the better results, they will receive. Applications will be programmed so that customers will always have the opportunity to see an overview over their data, to change and delete it as they see fit. Even in the application development phase, privacy and the different demands placed on data protection by the customers will be taken into consideration by designing and offering various convenience and privacy levels. In addition, testing companies will allow app users to have transparent access to the testing process of the corresponding product (privacy by design).

"You have to ensure that companies live up to their promises, which can be accomplished through independent third party reports and audits."

Dr. Ann Cavoukian, Executive Director Privacy and Big Data Institute, Ryerson University

Transparency and trust are very closely connected to blockchain technology. This type of technology, which also incorporates the cryptocurrency Bitcoin, will be used in many areas in 2027 and may also include the conformity assessment sector. The unchangeable storage of information in the blocks of a blockchain contains the promise that it will assume full responsibility for testing and certification towards the manufacturer as well as interested end customers. What sounds trivial will be an incomparable challenge for companies. As a consequence, all standards will shift, even in the field of applications and beyond the boundaries of blockchain technology: The public audit record is a certification product of the future. Contracts, test schemes, audit reports, etc., will be transparently comprehensible for authorized bodies.

More data = More Customers

The above developments illustrate that progressive conformity assessment bodies will soon transform their legitimate interest in taking on an active role in the growing data stream into a concrete system. The number of sensors which are used in the manufacturing process of products and continuously collect data from end customers will increase exponentially. This data will be supplemented by every form of communication with (end) customers across all channels. One task for this omnichannel management will be to not only manage all data across all stages of the testing process and of the customer dialogue, but to generate added value through intelligent analytics – down to the consumer and the optimization of the provider's own processes.

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collect data from end customers will increase exponentially. This data will be supplemented by every form of communication with (end) customers across all channels. One task for this omnichannel management will be to not only manage all data across all stages of the testing process and of the customer dialogue, but to generate added value through intelligent analytics – down to the consumer and the optimization of the provider's own processes.

Finally, the greatest transformation in the TIC industry will not concern a change of their existing clients and the corresponding strategies. In the context of digitalization, a completely new customer group will come to the attention of CABs: the customers of their customers. In short: B2B2C. This necessary consequence firstly offers an opportunity for CABs if they manage to occupy this interface between digital products and end customers faster than other new players. Consumer demands are obviously a given fact, but the trust relationship with established manufacturers is strained in many regards. It is most of all digital products that can fill this vacuum. These products can help consumers in choosing products, who will also take into consideration the individual safety score or statements from their peer group. "Customers like you also bought this product – be assured that it meets your safety requirements. Approved by community and CAB."

If customer data is not collected implicitly or as a white label through the manufacturer, other lucrative and attractive business models are nevertheless available. The main focus in terms of any seal-related principle is the increase of added value for end customers; individualized shopping recommendations in supermarkets which exclusively display gluten-free, organic, or calorie-reduced foods will be played back over the right medium – from the classic seal down to the digital seal of tomorrow solely based on augmented reality.



STRATEGIC RECOMMENDATIONS

How to make your company future-proof

The new demands placed on safety, on changed mechanisms in establishing norms and standards, and on the transformation of test objects and the process of testing, inspection, and certification reveal the extremely dynamic nature of the TIC industry. New impulses from the customer side, a new need for trust, and modern communication organization are orchestrating these requirements.

A number of effective short-, medium-, and long-term recommendations can be deduced from the insights of this study. Drawing on the basis of the theoretical research involved, the expert interviews, and orchestrated using proven methods for strategy and innovation development, the 2b AHEAD ThinkTank has formulated the thirteen most promising strategic recommendations, three for providers in industry, and ten for the TIC sector.

Recommendations for industry

- 1. Establish and use feedback channels:** The certification of a product at the time of purchase will increasingly move away from being a closed process, especially in the early days of adaptive products. This is partially because safety requirements will first emerge during product use (adaptive certification), partially because the basic framework will change with technological progress or new legislature, and partially because different customers will have different demands for precisely the same product. This will lead to more frequent occurrences of three-way communication between producers, users, and CABs. The construction – and later the actual use – of the appropriate channels and feedback channels is critical for ensuring seamless communication.
- 2. Offer every customer security by design:** For product, process, and data security, a number of mandatory requirements exist, primarily derived from regulations and laws. And in each of these areas there is room for optional moves that exceed the minimum standards in terms of safety and / or convenience – and which lead to correspondingly higher costs. The modularization of solutions (in large part caused by digitalization) can make it attractive for consumers to choose different providers for additional modules rather than remaining with the provider of the base product (the cappuccino principle). A transparent disclosure of mandatory and optional features in your product portfolio will enable diversification of your solutions while simultaneously protecting you from customer attrition.

3. **Create contact layers:** While the concept of the "interface" was long associated with a sharp transition between distinct, clearly defined systems, the borders between these systems have become greatly blurred in terms of institutions as well as processes. Where a company actually ends is hardly definable, and while it is possible to stipulate which parties will have which rights and responsibilities in a given project down to the finest contractual detail, reality refuses to submit.

As a result, clear interfaces are becoming increasingly rare at the fringe areas of companies (where CABs operate). A contact layer surrounding the company is a forward-looking construct: Like a cell wall, it allows various forms of exchange and communication, some of which penetrate to the inner core while others only affect the contact layer itself.

Recommendations for the TIC sector

1. **Position yourself as the digital safety assistant for your customers.** The

customer will integrate the intelligence of the system in the early stages of the development and production phases and will also be supported in the post-production phase. This data will be useful to you for developing new business models. Additionally, enable customers to easily switch between safety modules (data-driven, open and transparent, personalized, free of charge, autonomous).

2. **Position yourself as the digital safety assistant for your end customers as well.**

Do not sell customers safety, but trust. This is where continuous testing and safety is offered for the entire life of the product. Offer a variety of scalable safety levels. Because consumers tend to trust independent providers more, those that are not bound to a specific manufacturer will have good chances here.

3. **Establish omnichannel communication.** In omnichannel systems, every staff member has real-time access to all relevant information about the customer – at every touch point. Data is automatically interconnected and is also provided in the self-service customer interface.

4. **Rely on business partnerships** with manufacturers, providers of smart home solutions, and other promising emergent

industries. Take advantage of the benefits of open innovation and open source platforms in order to quickly and efficiently define standards for new technologies. Do not hesitate to establish partnerships with competitors; this will serve to exploit synergy potentials on the one hand, and your own specialization on the other.

5. **Constantly develop alternative business models,** in a digital accelerator for example, that attack the TIC business. Use this knowledge in order to prepare your company for the challenges that will emerge through players from outside of the industry.

6. **Rely on data-driven predictive maintenance.** Give the initial examination away for free. Your profits will come from every manufactured unit, from every transferred byte that is secure thanks to your assessment. The question of profit for the isolated instance of the opening assessment will thus become irrelevant in the long run.

7. **View experts and auditors as human / machine organisms.** Use the capabilities of digital systems and devices for yourself and simultaneously offer services that machines cannot provide. For some segments in the future, the combination of human and machine performance will be the sole factor capable of generating both trust and added value.

8. **Organize all activities in the company in a project-based and agile manner** instead of focusing on specific topics or following a linear approach. Knowledge management, as well as the ability to attract and accurately place highly qualified staff, will be the key qualification for TIC providers.
9. **Launch joint ventures with leading developers of simulation software** to ensure that realizing product certification can be as non-destructive as possible. Use blockchain technology for counterfeit-proof, transparent, and automatic product documentation.
10. **Build up competence in the field of artificial intelligence** in order to test AI. If in doubt, purchase external AI solutions as well. It is not the collection of data that will promise success, but its strategic evaluation. At the same time, promote the development of an electronic person to help address the question of liability in the context of autonomous testing.





THE AUTHORS

Scientist, trend researchers, and strategy consultants

Michael Carl



Michael Carl is Managing Director Research & Consulting at the 2b AHEAD ThinkTank. He is responsible for the methods and content of the institute's future studies, manages their implementation, and guides the development of specific strategic recommendations. He is

also a sought-after keynote speaker on trend and future-related topics.

After his studies in Theology in Germany and Great Britain, Michael was active in journalism, working as an editor and moderator for various public and private radio broadcasters. After several years as personal advisor to an ARD radio director, he moved to the corporate sphere. Initially Michael established and managed the strategy office of the Berlin Brandenburg radio network, where he was responsible for major structural, strategic, and HR projects. Michael is also experienced as an independent consultant for strategic and organizational development. His passions are music and his literature blog.

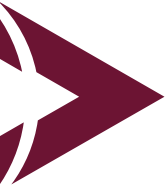
Kai Arne Gondlach



Kai Arne Gondlach is Senior Researcher at the 2b AHEAD ThinkTank. He is responsible for planning and conducting the institute's future studies and for developing the methods used by its research team. Aside from his scientific work at 2b AHEAD, Kai is an inspiring

keynote speaker who uses unsettling prognoses to lead his listeners outside of their comfort zones.

Finally, he develops innovative strategies and concepts together with the ThinkTank's customers in a variety of change projects. Before joining 2b AHEAD, Kai studied Sociology, Political Science, and Future Studies in Potsdam and Berlin. After graduating high school, he worked as an independent web developer and PC consultant for many years. Kai also held several posts in consulting companies and in the corporate strategy division of a major German mobility provider before becoming Innovation & Marketing Manager for a Berlin startup. In his private life, Kai is a devoted musician who enjoys singing and playing both guitar and piano. He is an avid squash player and loves discovering the world as a backpacker and cyclist.



THE METHODS

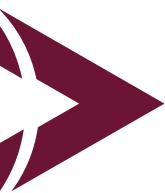
The delphi method and qualitative expert interviews

The present study is a qualitative, empirical study using the Delphi method. This method is a future-studies method that takes its name from the famed oracle of ancient times. It was developed during the middle of the last century in the US and is used for the preparation of forecasts. Because hardly any expert in these complex times is able to successfully observe several mutually influential fields of expertise at once, Delphi method studies draw on the assessments of several experts, each with their own specialist knowledge. The interviews are conducted using a two-stage process.

During the first phase, the experts are asked individually to give their personal assessments on specific topics over the course of guided expert interviews. In the second phase, in contrast, they are presented with the collective results of the first round. The experts are then asked to hold to their positions from the first phase, or to integrate the results of the first phase in a revised assessment of the subject matter.

The selection of the expert study participants is particularly important for this scientific approach to trend research. For this reason, a so-called "trend cycle" is compiled in a workshop format after an extensive desk research phase covering existing topic-related studies and publications. The trend cycle constitutes a list of all of those companies within and outside of a given industry

whose resources are sufficient to ensure that the strategic decisions they make today will have a significant effect on the future of the target industry, either because other players are sure to follow their example, or because they can successfully push their business models thanks to the influence they have over the market. One expert was chosen out of each relevant group of industry players who did not merely speak about their own company, but was also able to give an overview of their group. The pool of experts consisted of key players from the TIC industry, norms and standards institutions, technology providers, and attackers from outside the classical TIC industry. A total of 16 experts were chosen. The expert statements subsequently underwent a qualitative analysis and were divided into the following four trend areas: safety 2027; test objects; processes and business models of the TIC industry; customers & communication. These trend areas compile the essential statements given by the experts concerning the conformity assessment of the future. To close the study, strategic options for the TIC industry were derived from the trend areas. These recommendations are based on a synthesis of the exploration of the trend areas, the statements given by the experts, and the future scenarios, and also the expert knowledge of the 2bAHEAD ThinkTank in innovation management strategies.



THE EXPERTS

Investment decision makers, strategy leaders, and future experts



Dirk Backofen

Dirk Backofen, Head of Portfolio Management, Engineering, and Operations, Telekom Security

T-Systems is the largest service provider for information and communication technology worldwide. Dirk Backofen is the head of the business unit Telekom Security, and enriched our panel with his expertise in the field of IT security.



Josu Franco

Vice President Corporate Development, Panda Security

Panda Security is an international company for IT security. Josu Franco granted us exciting insights into the possibilities of adaptive and predictive online "pest control."



Dr. Ulrike Bohnsack

Member of the Management Board, Standardization Division, Deutsches Institut für Normung e.V. (DIN)

Not only in Germany, but across the world, the German Institute for Standardization is an authority for quality assurance through standardization and norms. Dr. Ulrike Bohnsack is the head of the standardization division and an expert in her field.



Lars Franzon

Vice President and CIO, Securitas Europe

Securitas is the world's largest provider of security solutions. In his role as Vice President and CIO, Lars Franzon gave us in-depth insights into two key areas: security and the digitalization of a major corporation.



Dr. Ann Cavoukian

Executive Director, Ryerson University, Privacy and Big Data Institute

Dr. Ann Cavoukian is Executive Director at Ryerson University's Privacy and Big Data Institute in Canada. She is also the innovative mind behind the concept of "privacy by design." With her theoretical and practical experience, Dr. Ann Cavoukian enriched this study with her insight into many aspects of handling data in a digital world.



Dr. Eckhard Hempel

Director Strategy Development, Siemens Healthcare GmbH & Principal Healthcare Consulting, Siemens AG

Across industries, Siemens stands for tradition as well as innovation. As an expert in the field of health care and building technologies, Dr. Eckhard Hempel was a great asset in providing an overarching perspective on digitalization in the context of the TIC industry.



Dr. Michael Feindt

Founder and Chief Scientific Advisor, Blue Yonder

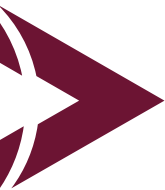
Dr. Michael Feindt is a pioneer in the field of predictive analytics, big data, and real-time forecasting. With his company Blue Yonder, he provides leading-edge technologies for business – and greatly enhanced our panel with valuable insights from his work.



Heinrich Herbster

Hekatron, Head of Market Development and Member of the Executive Board

Hekatron is an innovative provider of security solutions for fire and smoke detection and plays an active role in various standardization panels. Heinrich Herbster offered us an industry point of view for standardization and certification across different sectors and countries.



THE EXPERTS

Investment decision makers, strategy leaders, and future experts



Christoph Jentzsch
 Founder and CTO, Slock.it

Christoph Jentzsch of Slock.it has programmed an investment fund based on blockchain technology that functions without any staff or management – and set a crowdfunding record in the process. He enriched our panel with his perspective on autonomous, transparent, and secure IT systems.



Dr. Daniel Schneider
 Head of Embedded Systems Quality Assurance, Fraunhofer Institute for Experimental Software Engineering (IESE)

The Fraunhofer IESE is a leader in the field of safety research with regard to tomorrow's complex, networked, and also adaptive systems. Dr. Daniel Schneider complemented our expert panel at this interface between industry and the TIC sector.



Dr. Raoul Kirmes
 Head of Staff Unit II (Core Operations), DAkkS, (German National Accreditation Body)

Germany's national accreditation body DAkkS is the sole service provider for accreditation in Germany's TIC industry. Dr. Raoul Kirmes complemented our panel with his expertise in quality testing, certification, and risk assessment.



Stephen J. Scott
 Founder and CEO, Starling Trust Sciences

Starling Trust Sciences analyzes and optimizes the formation of trust in an institutional context through the use of leading-edge technologies. Stephen Scott is thus the ideal expert when considering trust models in the digital world.



Ulli Klenk
 Head of Additive Manufacturing Product Management & Sales, Siemens AG

That Siemens is striking out in a new direction is evident not only from the existence of its Competence Center Additive Manufacturing. Ulli Klenk explained to us the finer points of 3D printing technology and particularly opened our eyes to modern testing and certification modalities in this context.



Dr. Elisabeth Stampfl-Blaha
 Vice President (Technical Management), International Organization for Standardization (ISO)

Dr. Elisabeth Stampfl-Blaha is Vice President of the International Organization for Standardization (ISO) and Vice Director of Austrian Standards. She enriched our panel with her international perspective on the development of norms and standards.



Peter Oltmanns
 Director and CTO, Tomorrow Labs

Tomorrow Labs unites existing production infrastructure with digital systems and is thus one of the most important drivers behind Industry 4.0. Peter Oltmanns was our expert for cyber-physical systems and the digitalization of the production process.



Iñaki Urzay
 Chief Security Strategist, Panda Security

Panda Security is a global company for IT security. As chief strategist, Iñaki Urzay is well acquainted with security-relevant questions concerning digital products, and enriched our panel with his perspective on IT security.

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STUDY PARTNERS



The 2b AHEAD Think Tank is Germany's most modern institute for trend analysis and future studies, and employs both scientists and policy advisors. For its customers, the 2b AHEAD ThinkTank uses scientific trend studies to analyze both the opportunities and risks associated with trend developments in their business. The 2b AHEAD ThinkTank not only investigates within the target industry, but across industry boundaries, incorporating all stakeholders that shape the future of the respective business model. With its analysis, the 2b AHEAD ThinkTank helps its customers to understand who or what is driving their relevant trend environment, and for what reasons.

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The TÜV NORD GROUP has more than 10,000 staff members and is one of the largest providers of technical services in the world. With leading expertise in the areas of consulting, service, and testing, the group serves customers in 70 countries worldwide. It's core business areas are production, service, mobility, IT, and education. With its services in the fields of natural resources and aerospace, TÜV NORD differentiates itself industry-wide. It's guiding principle: "Excellence for your business."

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In 1866, TÜV SÜD was founded as a steam-boiler inspection association. Today the company is one of the world's leading providers in the business of testing, assessment, auditing, certification, training, and expertise. With roughly 24,000 employees across more than 800 locations, we are represented in 50 countries and enable the optimization of technology, systems, and know-how. Independent and nonpartisan TÜV SÜD experts significantly contribute to making technological innovations such as Industry 4.0, autonomous driving, or renewable energies safe and reliable.

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GLOSSARY

adaptive products

Product feature which describes products or services that are both individualized and situational, and adapt to the respective needs of the user even after being purchased.

assistance systems, digital / electronic

Software (e.g., smartphone apps) for customer advice and support which gives recommendations based on data analysis. Services providers and third parties can – among other things – use these systems to offer customers individualized products. The precursors of this system are today's comparison portals.

big data

Denotes enormous heaps of data too large to be evaluated by human effort alone. This data results mainly from the evaluation of internet usage, but also from other devices such as cameras, microphones, etc. In order to process this data mass, new technologies and analytical systems are necessary.

blockchain

Blockchain technology makes it possible to transact digital exchanges without a middleman. All transaction-related information is stored in a decentralized system, which increases transparency and also ensures that network information cannot be altered or counterfeited. The most common examples of blockchain are the cryptocurrency Bitcoin and Ethereum-based smart contracts for insurance.

caring companies

Caring companies have a corporate culture of staff appreciation, and have a strong focus on long-term employee retention, as well as on a strong commitment to the social environments of their team members.

cloud

An IT model in which data is not saved on dedicated hardware (e.g. hard drives), but rather on the internet so that it is available at any time from any location having an internet connection. The safest alternative to cloud computing is so-called fog computing.

cognitive computing systems

Cognitive computer systems develop the ability to understand humans, to learn from them, and to independently make decisions based on learning algorithms and artificial intelligence.

fluid companies

Companies with an HR strategy that is professionalized in the field of skillfully attracting and purposefully jettisoning project workers according to operational needs. For the most part these are globally oriented companies dependent on a continuous flow of highly qualified knowledge workers.

human / machine organism

System for contact and interaction between humans and devices, often with the use of technological support from sensors or displays such as augmented or mixed reality devices.

Internet of Things / Internet of Everything

The Internet of Things refers to the increasing networking of all production facilities, products, and devices in everyday life and in business. Over the next few years, every object will be connected to the internet through its own IP address.

M2M

Machine-to-machine interaction refers to information flow and automated communication between terminals – containers, shelves, products, vehicles, etc. – which allows an increasing level of autonomous processes in production and logistics.

Moore's law

A law which states that the computing power of computer chips, calculated according to the number silicon transistors on a chip, will double approximately every 18 months at a constant price. Moore's law has been valid since the 1950s.

omnichannel management

A continuation of the multichannel or cross-channel approach. The coordination and control of the activities of all company departments according to the strategy of creating a unified one-to-one experience for the customer, across all communication and touch points and without media interruption.

predictive analytics / smart forecasting

Predictive analysis refers to an approach which combines different statistical methods – such as data mining and fact finding – in order to generate forecasts. This technology enables, for example, an early recognition of customer requirements and thus the ability to offer a product that has already been individualized to fit the customer's needs (if they so desire).

TIC industry

Testing, Inspection and Certification: The TIC industry refers to all state-licensed companies which conduct the assessment, testing, inspection, auditing, and certification of products, plants, processes, and individuals.

trend cycle

A compilation of all those businesses, both within and beyond a given industry, which possess sufficient resources that the strategic decisions they make today will have a significant influence on the industry's future.



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