

Industry Trends 2025

Results from the Vector Consulting Survey

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Vector Consulting Services

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The Return of the Magic Triangle

The magic triangle is back. At year-end 2024, Vector Consulting surveyed industry experts about their challenges and resolutions. Not surprisingly competitive pressure dominates the feedback. We observe a new magic triangle of cost, quality and innovation. Four risks were mentioned, ranging from misunderstood agility to the focus on “Everything as Code” (EAC) with insufficient test and hardening. Rework, technical debt and liability risks increase and will impact cost.

The answers reflect the perceived competitive pressure worldwide. Fig. 1 shows the perceived challenges across industries and worldwide. The horizontal axis shows short-term challenges, while the vertical axis represents medium-term obstacles. Each respondent was able to name up to five challenges in both dimensions. The total is therefore more than 100 percent. We observe a magic triangle of cost, quality and innovation. In our interviews with software and IT management and developers four risks were mentioned:

- ▶ **Innovation trap:** Traditional OEMs and suppliers are struggling with the demands placed on technology and corporate management with a simultaneous lack of capacity and expertise. Impact: Downward spiral for established companies that do not bring enough new products to market.
- ▶ **Cost trap:** The worsening global economic climate requires cost reductions and a misunderstood “right-sourcing”. Impact: Insufficient focus on safety-critical development reduces quality and causes rework and recalls with additional costs.
- ▶ **Agility trap:** Perceived pragmatic patchwork processes invite “anything goes” as processes are not taken seriously. Impact: Increasing governance risks with high risk of supplier audits, competitive disadvantages and recalls and associated costs.
- ▶ **IT trap:** Trends from application development are used in safety-critical systems, such as “Everything as Code” (EaC) and DevOps. They accelerate development, but at the cost of insufficient contextual understanding and a lack of security. Impact: Growing technical debt and security risks with corresponding costs and delays.

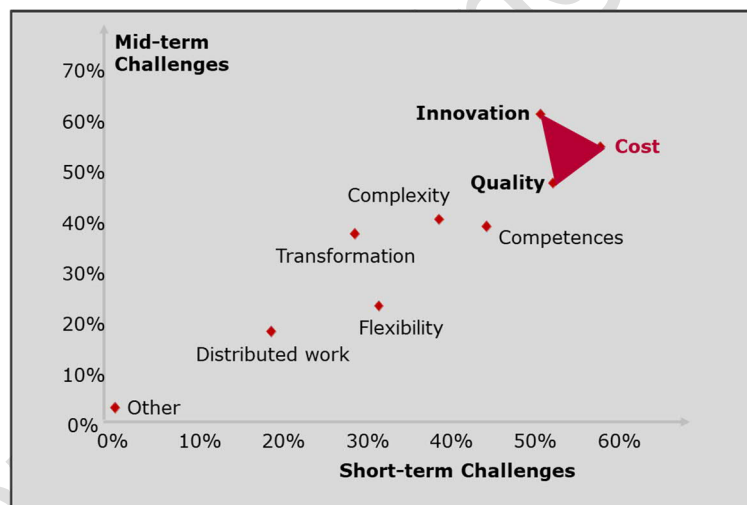


Fig. 1: The Magic Triangle of Competitiveness: Innovation, Cost, Quality

The current one-dimensional focus on only cost reduction is leading to a downward spiral, as our interview partners pointed out. Engineers and companies know in theory what they should do in practice, but they often lack the necessary processes and management support to put it into practice. The mere focus on cost reduction alone undermines the ability of companies to innovate. Given the parallel loss of competences, our interview partners see quality decreasing and technical debt increasing. Misunderstood agility and disappearing process capabilities, result in dangerous risks [1].

Take cybersecurity, for example: IT solutions from the cookbook are of little help in critical environments. What is needed here are concrete instructions on how the standards can be implemented efficiently and in interaction with each other. Cybersecurity and safety can only be achieved sustainably across variants and versions if systems engineering, and lifecycle management are linked.

The mere focus on cost reduction alone undermines the ability of companies to innovate.

Interview partners emphasize that systematic development of critical systems is a top priority with growing safety hazards and cybersecurity threats. At the same time, engineering capacity is reduced with tasks remaining unchanged. GenAI "co-pilots" are seen as an engineering substitute with growing quality and IPR risks. Examples were brought forward to us indicating that in search for more efficiency some traditional software tasks are currently enhanced by generative AI (GenAI). Proper development of critical systems is of increasing relevance as it needs professional process and deep technology expertise, which a chatbot will not have, and which from liability and insurance perspective cannot be outsourced to such chatbot.

Software Technology and IT Trends

Technology is fast evolving and needs profound guidance. Our annual survey and interviews with lots of business partners and industry experts across the globe provides a summary on relevant trends. To get own hands-on exposure to technology, let's have a look to the global "fashion show", namely Consumer Electronics Show (CES) 2025 in Las Vegas. CES is the leading trade fair for all kinds of "consumer electronics", from smart homes, ecology and medical technology to data centers and robots, industry automation, vehicles and mobility. Recent CES had over 4,500 exhibitors with industry giants such as Nvidia, Samsung, and Siemens, but also 1,400 start-ups. There were 141,000 visitors with an increasing share from Asia. One third of exhibitors came from China with a clear growing trend.

Misunderstood agility and disappearing process capabilities, result in dangerous risks.

AI is clearly leading the innovation headlines, ranging from software development co-pilots to smart home and health gadgets with artificial intelligence (AI) up to latest technology. The high proportion of Chinese companies and visitors was surprising. Europe was lagging as were generally automotive companies which until last year almost dominated the CES with their innovations. The current economic decline was tangible, even by just measuring the loudness in the halls. Consumer goods were colorful and loud, while the automotive booths in west hall of Las Vegas Convention center were rather quiet and sober.

Three major themes and trends can be recognized that we will dive into:

- ▶ Consumer, Health and Home
- ▶ Industry and Automation
- ▶ Automotive and Mobility

Consumer, Health and Home: AI and Sustainability

Traditionally separated domains of enterprise IT and product IT are converging [2]. IT these days is dominated by AI and sustainability. AI is increasingly integrated into everyday consumer products. Products range from AI-powered devices, from smart homes to health-monitoring wearables, laundry machines and a huge amount of home entertainment, such as latest high-definition TV screens. Augmented reality is converging with AI. Innovations such as AI-enhanced smart glasses capable of real-time translation and augmented reality overlays. Consumer experiences get almost daily more immersive and interactive. Companies such as Samsung and LG currently showcase AI-driven home appliances that adapt to user habits, optimize energy efficiency, and enhance convenience. In healthcare, IoT-enabled wearables for everyday health surveillance from fitness tracking to real-time health monitoring and early disease detection. Medical devices highlight for instance smart insulin pumps and AI-assisted diagnostic tools. AI-assisted diagnostic tools now analyze voice patterns, eye movements, and skin conditions to detect early signs of diseases such as Parkinson's and cardiovascular disorders. Remote patient monitoring solutions are also gaining traction, reducing the need for frequent hospital visits. AI-powered medical IoT devices allow doctors to track patients' vitals in real-time, improving healthcare accessibility, especially in remote areas. However, concerns over patient data security and regulatory approval processes continue to shape the adoption of these technologies.

Industry and Automation: Connectivity and Convergence

Connectivity drives the industry domain with IoT highlighting advancements in industrial automation, healthcare, and smart city technologies [2]. Automation matters along the lifecycle with many experts disappearing into retirement. Humanoid robots are seen as an alternative that ease human collaboration but could also serve in a variety of environments from healthcare to production. Fig. 2 shows an example in manufacturing. Edge computing solutions and edge AI will reduce latency and improve efficiency by processing data closer to the source. This is particularly relevant in manufacturing, where real-time data analytics enhance predictive maintenance and minimize downtime. IoT once thought to bridge industry domains with the many organically grown proprietary protocols and stacks seems to rather propagate old habits. Interoperability between IoT devices remains a persistent challenge. OEMs exhibit amazing robot technology yet operate within proprietary ecosystems. Seamless integration across different platforms difficult while promoted in flyers and headlines, remains a wishful thinking and slows down innovation. Standardization efforts are underway over decades, but the lack of universal protocols continues to hinder widespread IoT adoption. With billions of connected edge devices, machines and entire supply chains, vulnerabilities in industrial IoT systems can lead to significant disruptions. To mitigate, companies are investing in AI-driven security solutions capable of identifying and mitigating cyber threats in real time, as we learned from a Siemens executive. An increasing amount of governance and compliance even punish those companies who try to obey rules and behave correctly.

Automotive and Mobility: Smart Transportation

Rapid advancements are tangible in electric vehicles (EVs), autonomous driving, and AI-powered mobility solutions. While autonomous vehicles have reached the valley of disillusion, more pragmatic topics such as augmented reality and AI powered user experience gain attention. Harvesting machines converge classic agriculture with backbone software systems to integrate ERP, and maintenance. Automakers evolve next-generation EVs with improved battery efficiency, reduced charging times, and extended range capabilities. BMW, Hyundai and Tesla currently work on concept cars with solid-state batteries that are expected to revolutionize energy storage in the mobility industry. AI-driven in-car assistants and augmented reality dashboards are major trends, enhancing driver experience and safety. They offer real-time traffic analysis, personalized entertainment and identifying hazards. Potential over-reliance on AI in driving decision-making emerges as a new risk along with cybersecurity, as we learned in our interviews with automotive experts. Japanese manufacturer Suzuki showed at CES 2025 an autonomous electric platform in small car format, which is intended to counteract the shortage of drivers in logistics. Another company even showed a drone that can be loaded to a small truck, thus integrating land and air transport. AI-powered self-driving systems rely on enhanced sensor fusion and machine learning algorithms. These systems promise safer and more efficient transportation but face regulatory and ethical challenges. The deployment of fully autonomous vehicles remains limited due to unresolved legal and liability concerns.

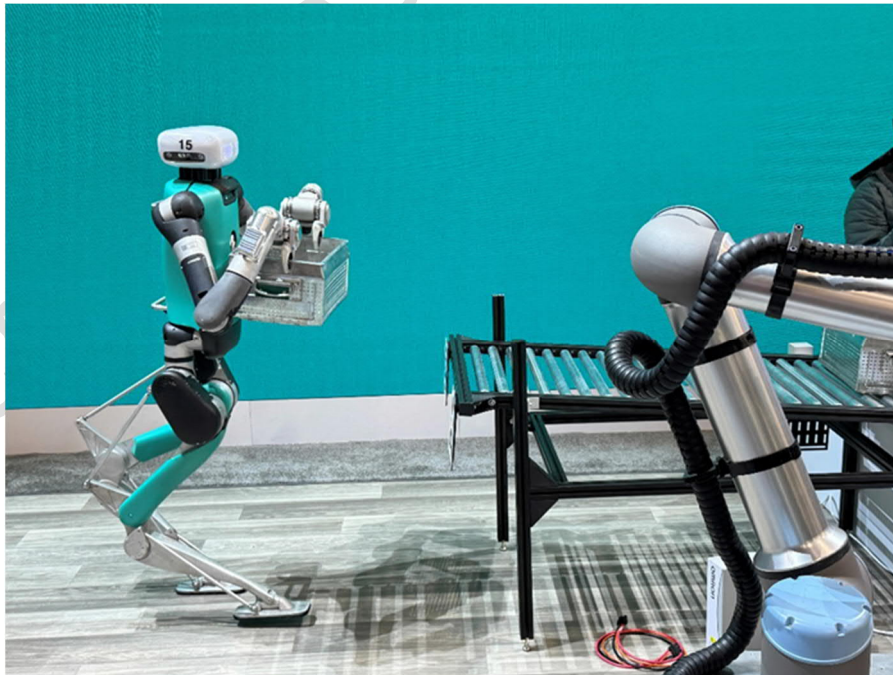


Fig. 2: AI shapes the technology landscape (picture rights with author)

Test matters—But Is Not Mastered

We asked about the major business risks in the respective companies and how they relate to quality. Fig. 3 provides the results. Each respondent could name a maximum of three impacts which explains why we see a sum of over 100%. Perceived project risks are dominated by two factors which mutually impact each other, namely::

- ▶ Increasing amount of test effort.
- ▶ Need for enhanced V&V efficiency.

The rather modest test efficiency across industries means that the amount of test piles up. Worse yet, lack of systematic testing also means that not only effort is wasted, but also that test has a growing number of blind spots. Often we see companies that run zillions of automatic unit tests, but do not have a clear coverage strategy. Regression testing is done primarily on a time-boxing scheme than based on risk and criticality. Adaptive and learning systems are often tested only on straight-forward functions and brute-force test cases, but not with systematically derived corner cases.

Software and IT companies have observed a significant increase in testing effort over the past years. This rise is driven by growing system complexity, stricter regulatory requirements, and the widespread adoption of AI, IoT, and cloud-based solutions [3]. Despite this, defect detection often occurs too late in the development cycle, leading to increased costs and project delays. The following key observations from our 2025 industry trends survey highlight the challenges and necessary improvements in Verification and Validation (V&V):

Test Effort Has Been Increasing. Most survey respondents underlined that while test is consuming an increasing amount of effort, the impact is not as tangible. Industry reports from Capgemini's World Quality Report show that testing now accounts for up to 30-40% of total development costs, driven by the need for continuous integration/continuous deployment (CI/CD) pipelines, automated testing frameworks, and security compliance checks. In safety-critical systems such as automotive and medical this effort is even beyond 50% over lifecycle cost [4]. However, despite increased test investments, defect detection remains inefficient, leading to costly rework in later phases.

Need for Better V&V Efficiency. Many organizations still rely on manual testing for critical validation, resulting in bottlenecks [3]. Test automation adoption varies across industries, with DevOps-driven teams achieving higher efficiency through AI-based test case generation and self-healing test automation. However, traditional industries (e.g., automotive and medical devices) struggle to integrate V&V improvements due to regulatory constraints, requiring better risk-based testing strategies.

Defects Are Detected Too Late. The well-known Cost of Change Curve, as introduced by Barry Boehm and underlined by studies in IBM, Google and others, shows that defects found during system testing or production are exponentially more expensive to fix than those identified in earlier phases [4]. Late defect detection leads to increased rework, delayed releases, and potential security vulnerabilities, necessitating a shift-left approach with early V&V integration.

Insufficient Requirements Quality Impacts Testing and Defect Rates. Poorly defined requirements cause misunderstandings, ambiguous test cases, and unnecessary rework. According to the IEEE Software Engineering Body of Knowledge (SWEBOK), unclear requirements contribute to over 50% of software failures. Improving requirement clarity, traceability, and automated requirement validation tools, such as natural language processing for detecting inconsistencies can reduce defect injection at early stages [5,6,7].

Quality Requirements Are Not Sufficiently Tested. Non-functional requirements (e.g., performance, security, and reliability) are often under-tested due to unclear definitions and a lack of dedicated test environments. Studies by the ISTQB suggest that many teams focus primarily on functional testing, leaving quality attributes like usability, scalability, and fault tolerance inadequately verified, leading to unexpected failures post-release.

Need for Better V&V Methods to Detect Critical Defects. Traditional testing approaches struggle to identify critical defects in complex, AI-driven, and cyber-physical systems. The use of AI-powered anomaly detection, mutation testing, and formal verification methods (widely used in safety-critical industries like aerospace and automotive) can improve defect detection rates. Companies like Google and Microsoft integrate ML-based defect prediction models to proactively identify high-risk code areas.

Insufficient Regression Testing. Regression test coverage often declines due to time constraints and increasing system complexity. Automated regression testing with AI-driven test case prioritization (e.g., used by Netflix and Meta) can enhance efficiency by focusing on high-impact areas while reducing redundant tests. Implementing more intelligent testing, such as cognitive testing methods, model-based testing (MBT) and synthetic test data generation can further optimize regression cycles.

The rapid growth of software complexity necessitates a fundamental shift in V&V strategies. To remain competitive, IT and software companies must invest in AI-driven testing, better requirements engineering, and early defect detection through shift-left testing. Adopting risk-based and automated approaches will enhance quality, reduce costs, and improve overall software reliability.

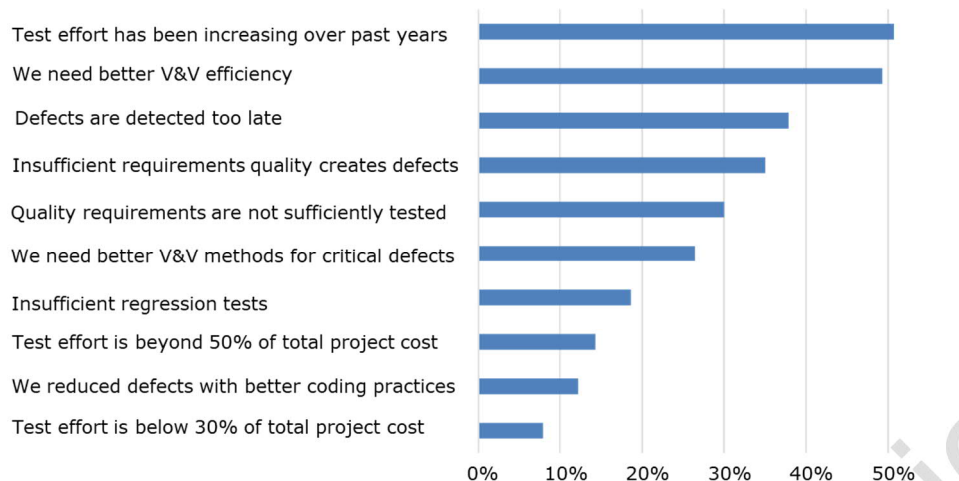


Fig. 3: The Magic Triangle Increases Quality Risks

Distributed Work: Back to the Office

Most companies are changing since 2024 their presence work towards mandatory 2-3 days per week in office. Immediate personal commitment and close task management are necessary because not everybody working from home and without direct supervision will deliver as planned. Remote work or "home-office" cocooning has stimulated a commitment divide which is hard to recuperate from. One part of the team is highly committed and is working in task forces and on weekends. Others are neither visible nor delivering. The situation cannot be repaired by technology alone but needs leadership which takes benefit of the described tools to motivate and follow up. Good use of collaboration methods and tools will help integrating the entire teams to tasks – with visible participation and progress.

Engineers are people, and people need social interaction. Working entirely remote reduces creativity and thus software productivity. Studies show that attribute substantial disadvantages to creative exchange due to remote work [6,7]. Software though digital in purpose is driven by human features if we see it as a creative work [8]. Leading tech players are moving back to defined workdays in office. Apple's chief AI manager has called back employees. The inflexible remote working policy of Apple has been reducing creativity and in turn innovation capabilities. With working from home collaboration across groups is heavily reduced and thus impacts the ability to process new and complex information. People work in their known teams, but do not grow new networks. While ad-hoc task productivity may go up with the perceived freedom of working from home, long-term productivity and innovation is decreasing [6].

Some of the companies we are working with observed that a big part of their engineering teams degraded in terms of commitment and quality. Some have started to release workforce. A seasoned software manager remarked that "distributed work can impede seamless communication and collaboration, crucial in complex, global projects."

Our recommendation is clear: Enforce rules for mandatory office time to bring people back to their colleagues and stimulate interaction. Encourage more traditional connects within the team such as periodic meetings within the team, hands-on mentoring, and solving problems in groups. Facilitate building new networks within the organization with informal meetings, such as a "happy hour" in presence. This stimulates team spirit and strengthens the corporate culture towards more networking and thus improves innovation and productivity.

Encourage more traditional connects within the team such as periodic meetings within the team, hands-on mentoring, and solving problems in groups.

Having two to three days in the office seems to balance the need for creativity and innovation with the demand for flexible work formats. Tech companies, such as Microsoft, are already promoting hybrid model with a mix of work from home and office work and demand staff to work from the office between two and three days a week. Elon Musk might be right in saying "If you don't want to go back to the office, you should pretend to work somewhere else and quit."

With an increasing amount of GenAI, engineers and engineering management need to change soft skills [6,7]. Tools and techniques to grow own competences are shifting. Classic classroom formats are not anymore relevant in times of distributed teams. Increasingly engineers use online formats for trainings.

Fig. 4 provides insights into media usage to grow own competences. Each respondent could name a maximum of three channels which explains why we see a sum of over 100%. Search tools, podcasts and online videos dominate the access to new information. It looks as if individual engineers prefer free formats, even at the cost of not knowing about the reliability of contents in such formats. One reason is the decreasing investment of their employees into formats with higher quality such as trainings. Many companies consider training and competence growth a cost factor, rather than investment. In the project heat, trainings are canceled first.

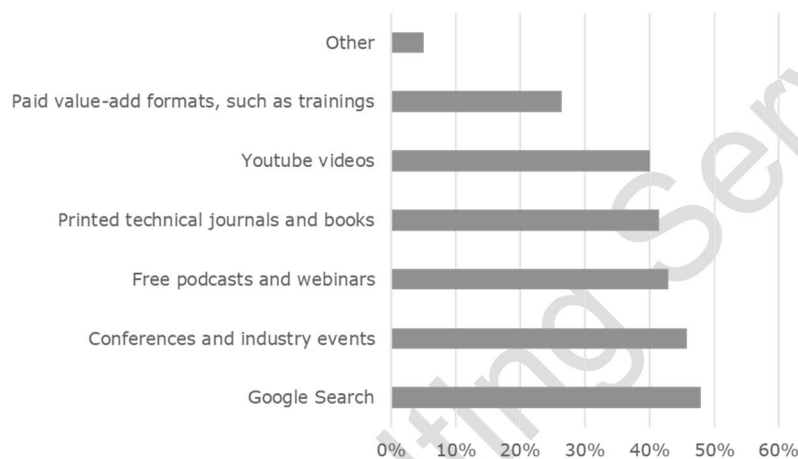


Fig. 4: Media usage to grow own competences.

Integrating the Trends

The technology industry faces several pressing challenges, with regulatory compliance becoming a critical concern [5,8,9]. Cybersecurity is a growing issue as AI becomes more prevalent. With smart devices continuously collecting data, experts warned about potential risks of data misuse. The good news is that consumers increasingly demand transparency in how their personal data is handled, pushing manufacturers to implement stricter security protocols and encryption measures. The integration of AI and IoT in healthcare raises ethical and regulatory concerns, with experts emphasizing the need for stringent data security measures to protect patient privacy.

Governments worldwide are enforcing stricter AI and data privacy laws, particularly in regions like Europe, Korea, and Japan. These evolving regulations require companies to prioritize transparency and adapt to rapidly expanding AI standards, influencing how AI-driven solutions are developed and deployed. The digital divide is deepening, now accompanied by an emerging AI divide. While high-tech solutions continue to attract early adopters, broader accessibility depends on affordability and ease of use. Ethical concerns around generative AI persist, particularly regarding misinformation and deepfake content. To counteract these risks, companies are developing AI verification tools to authenticate digital content.

Balancing technology progress with environmental responsibility remains a challenge, as innovations often come with increased resource consumption. Sustainability thus is considered a relevant decision-driver along supply-chains especially in Europe and East-Asia. It must be driven with a systems engineering perspective, integrating ecological, economic, and social factors. Manufacturers are adopting sustainable practices throughout the product lifecycle, using green IT, energy-efficient designs, and longer-lasting components. Software-Defined X is a key paradigm change, driven by the smartphone industry that uses extended software updates to reduce electronic waste [2]. The growing adoption of AI and connected devices is significantly increasing energy demands, particularly for data centers and AI model training [6,7]. Experts emphasize the need to address electronic waste, sustainable sourcing of raw materials, and energy-efficient manufacturing. While European initiatives are advancing green energy solutions, other regions continue to expand their carbon footprint.

with an increasing number of data centers powered by fossil fuels. Some companies are shifting focus toward sustainable mobility and energy solutions, reducing reliance on traditional tech-driven product lines.

Our business environment is increasingly uncertain with rapid changes. To thrive in this time of continuous change, companies and each single engineer need resilience to accept sudden changes and agility to immediately exploit the emerging opportunities. This demands a continuous learning to adapt to change and to adopt new practices. Technology evolution is driven by AI, connectivity, and sustainability. Companies and policymakers must collaborate to ensure responsible innovation and bridge the technological divide. As industries navigate these challenges, they must seize opportunities to create a more inclusive and sustainable digital future.

Where Do YOU Go from here?

We have asked our global consulting competence on what they recommend as take-aways. Here some hands-on guidance and key take-aways from our consulting projects. Use them for transfer to your own environments:

- ▶ **AI Everywhere:** Artificial intelligence is increasingly integrated in workflows and products across industries, from interacting bots to smart home assistants and robotic automation, across domains. AI is driving innovation for instance in augmented reality, content creation, and digital assistants or co-pilots that enhance productivity and user experience. Current AI models demonstrate improved contextual awareness, better natural language processing, and greater adaptability, enabling smarter, more intuitive interactions across various platforms and devices.
- ▶ **Sustainability:** As environmental concerns grow, companies must focus on sustainable product design, energy-efficient technologies, and ensuring longer device lifespans. Green IT plays a pivotal role, impacting all software domains. Sustainability will evolve especially in Europe and East-Asia a key competitive differentiator, shaping corporate strategies and influencing consumer purchasing decisions worldwide.
- ▶ **Automotive:** Despite economic downturns impacting the automotive sector, advancements in electric vehicles (EVs) and autonomous driving technologies continue. Innovations such as solid-state batteries promise longer range and faster charging, while AI-driven driver assistance systems enhance safety and efficiency. Additionally, investment in charging infrastructure and vehicle-to-grid integration is expanding, ensuring that electrified mobility becomes a cornerstone of future urban and intercity transportation networks. A major cost driver is verification and validation which today eats over 50 % of lifecycle cost. Companies must rework their testing processes and infrastructure. Cost efficiency of R&D and engineering is critical, which demands agile processes, and a much better connect of standards as is currently visibly. Distributed R&D must improve with global IT and SW supply chains ensuring functional safety and compliance of components.
- ▶ **Healthcare:** The healthcare sector is experiencing a digital revolution with AI-powered diagnostics, smart wearable health devices, and remote patient monitoring solutions. AI is improving early disease detection, treatment personalization, and hospital workflow optimization. Advanced biosensors and IoT-enabled medical devices enable continuous health tracking, allowing medical professionals to provide proactive care. However, software literacy in the medical sector, along with cybersecurity, regulatory compliance, and efficient processes must significantly improve to allow widespread adoption.
- ▶ **Cybersecurity:** The rapid adoption of AI raises significant cybersecurity concerns, particularly around misinformation, deepfake technology, and privacy breaches. AI-generated content can be exploited for deception, posing risks to your products, such as introducing unwanted backdoors. As more devices become interconnected, the attack surface for cyberthreats expands, demanding robust AI-driven security measures. Companies need to deploy real-time threat detection systems and enhanced encryption technologies to safeguard their IPR and sensitive data.
- ▶ **Regulatory Uncertainty:** Governments worldwide are implementing evolving AI and data privacy regulations, creating compliance challenges for global businesses. Differences in regional laws, such as the EU's AI Act and various national cybersecurity mandates, require companies to navigate complex legal landscapes. In the IoT sector, the absence of standardized protocols further complicates seamless device integration across ecosystems, slowing widespread adoption and increasing costs for developers and manufacturers.
- ▶ **AI Divide:** While cutting-edge AI solutions continue to emerge, accessibility remains a challenge, particularly in developing regions. High costs, digital literacy gaps, and language barriers limit widespread adoption. Additionally, AI models are often trained on biased datasets, leading to exclusionary outcomes. Companies must prioritize inclusive design, multilingual AI models, and affordable access to AI-powered tools to bridge the gap and ensure equitable technological benefits across all demographics.
- ▶ **Process and methods:** Many companies lack systematic methodology. Go beyond technology competence. Engineers love the technology stack and certainly know what is relevant for their work. Yet they often miss to look beyond today into evolving business

needs. A case in point is the growing impact of GenAI, both as productivity driver, e.g. code generation and test support, but also as a risk, e.g., intellectual property rights and degrading own competences.

- ▶ **Competence growth:** Agree individual and team learning targets at least on annual basis in the performance reviews. There is no evolution without measurable targets and actual feedback. Check the learning and commit to measurable learning objectives. Establish systematic competence evolution by competence grid for each basic role. To motivate growth a competency matrix should show an advancement path from junior to expert and how to grow with self-learning, mentoring, classes, hands-on projects, etc.
- ▶ **Knowledge management:** Use innovative technologies for knowledge management. GenAI is today often considered as a major knowledge source, yet needs not only intelligent prompts, but also careful filtering to highlight what matters and withdraw hallucinations. While it is relevant to deploy standard tools, such as SharePoint and collaboration tools, personal and organizational processes to share and grow competencies are more relevant.
- ▶ **Learning culture:** Encourage informal interactions across the team and open sharing of thoughts, ideas, and concerns. This means to get back into office and physically interact with colleagues. Remote work is ok for mechanical tasks and project management, but not for thinking out of the box and generating new ideas. Ensure that formal meetings and communication are timely, transparent, and widespread. Many meetings have long topic lists but no take-aways and no sustainable learning. Start with what one or more persons have learned in the past week. Use open issue lists to systematically follow up and close items.

Obviously these challenges demand more competence than most companies bring. You can't solve problems by using the same kind of thinking you used when you created them — as Albert Einstein underlined. Use the support of industry experts who actually walk the talk. Vector Consulting Services brings latest industry know-how that is proven in practice by being ourselves a leading software company.

You can't solve problems by using the same kind of thinking you used when you created them.

Acknowledgment

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