

Industry 5.0:
Convergence
at the edge of
innovation



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Executive Summary

This report—part of the annual **UST THINKING AHEAD SERIES** – explores the rise of Industry 5.0. This transformative evolution moves beyond the automation-led era of Industry 4.0 to usher in a future defined by human-centricity, collaboration, and ethical innovation.

Drawing on in-depth interviews with global business leaders and insights from a comprehensive **international survey** conducted by Hanover Research for UST, this edition uncovers how advanced technologies and human ingenuity are converging to reshape the fabric of industries worldwide.

Industry 5.0 places people back at the center of innovation. Organizations are preparing proactively for this shift, motivated by the potential for greater operational efficiency, improved customer experiences, and more meaningful human-machine collaboration. Rather than replacing human roles, intelligent technologies —like AI, IoT, robotics, digital twins, and custom silicon—are being harnessed to augment human potential.

At the core of this movement is silicon engineering, which powers the intelligence behind next-generation systems. Custom chip development is emerging as a key differentiator, enabling faster, more secure, and highly specialized applications across sectors. From manufacturing and healthcare to energy, mobility, and supply chains, the report illustrates how Industry 5.0 is driving tangible impact by aligning real-time automation with ethical, human-focused design.

As part of the UST Thinking Ahead Series, this report offers strategic guidance and a data-informed roadmap to help organizations navigate Industry 5.0, balance innovation with responsibility, and unlock a more resilient, inclusive, and forward-looking future.

FOREWORD BY

Krishna Sudheendra

Chief Executive Officer, UST



Welcome to the future — a future where technology and humanity converge in remarkable ways. Industry 5.0 marks a paradigm shift from the automation focus of Industry 4.0, embracing a more collaborative, human-centric approach that redefines how we interact with machines. It is not just a technological evolution but a profound transformation in how we think about innovation, efficiency, and ethics in a rapidly changing world.

At the heart of this transformation is the seamless integration of advanced technologies — AI, IoT, robotics, digital twins, and custom silicon engineering — all working together to enhance human potential rather than replace it. As businesses, our role is not just to respond to this change but to lead it.

This report offers insights into how pioneering organizations are navigating this journey, leveraging technology to build a more agile, efficient, and sustainable future.



The numbers speak for themselves. An impressive 75% of businesses already feel equipped to adapt to the demands of Industry 5.0. The promise of significant gains drives this readiness: 76% of organizations foresee substantial enhancements in operational efficiency, while 66% predict transformative improvements in customer interactions and experiences within the next five years.

What sets Industry 5.0 apart is its commitment to ethical and responsible innovation. An overwhelming 80% of organizations recognize that the ethical use of technology is not just desirable

but essential, while 78% emphasize the importance of human-centric solutions and seamless human-machine collaboration. This forward-thinking mindset reflects a new era where technology serves as an enabler of human achievement rather than an end in itself.

At UST, we are at the forefront of this evolution, empowering our clients to harness the power of AI and IoT to make real-time, data-driven decisions and achieve intelligent automation. Our approach prioritizes agility, security, and efficiency while fostering sustainable and responsible AI adoption.

This report captures the pulse of this transformative era, offering strategic insights and practical guidance to help you navigate the complexities of Industry 5.0.

I invite you to explore these findings and envision how your organization can thrive at the edge of innovation. Happy reading.

Together, let's engineer a future where technology and humanity work hand in hand to shape a better world.



Christine Dunbar
Head of Strategic Business
Development for Natcast



“Industry 5.0 is where human ingenuity meets intelligent automation, transforming semiconductor manufacturing with unprecedented precision and sustainability.”

Industry 5.0 and the semiconductor revolution

When I think of Industry 5.0, I see it as the next generation of manufacturing—one that goes beyond automation and embraces intelligence. It's about integrating AI, smart automation, and digital transformation to augment human capabilities rather than replace them.



Nowhere is this more critical than in the semiconductor industry, where complexity defines every aspect of the value chain, from design and fabrication to supply chains and sustainability.



Transforming semiconductor manufacturing

The semiconductor industry is ripe for transformation, and Industry 5.0 is accelerating the shift. Semiconductor manufacturing has always been complex, but we now have the tools to handle this complexity precisely. AI is reshaping everything—from optimizing chip design to managing intricate supply chains and meeting stringent environmental constraints. The potential efficiency gains in cost, performance, and sustainability are unprecedented.

Traditionally, semiconductor manufacturing focused on performance and cost, often overlooking factors like energy consumption, water usage, and ethical sourcing of materials. But that's changing.

Take Apple's first clean energy initiative announcement, for example. At the time, the commitment to achieving 100% clean energy across its entire supply chain and throughout the lifecycle of every product by 2030—known as "Apple 2030"—seemed ambitious.

Since then, the vision has not only evolved but has become even more ambitious—and, crucially, more achievable than ever. How? Innovations like AI-powered tools are enabling companies to reach these goals with unprecedented precision within factories. As the race toward carbon neutrality accelerates, AI is unlocking solutions once thought impossible.





The custom silicon movement

One of the biggest trends in the semiconductor industry today is custom chip development. The semiconductor shortage forced companies to rethink their dependence on standard chip suppliers, and now tech giants like Amazon, Microsoft, and even automakers are designing their own silicon. This shift isn't just about controlling supply chains—it's about securing a competitive edge. Companies that can develop custom chips tailored to their specific workloads and business needs are positioning themselves as leaders in the next phase of computing.

Advice for business leaders

For business leaders, the message is clear: success in Industry 5.0 requires a strategic approach. It's not about adopting technology for the sake of it but leveraging AI and automation to meet business objectives. The future belongs to companies that can seamlessly integrate intelligence into their operations while maintaining a human-centric approach.

Silicon engineering and chip development: The foundation of Industry 5.0



As Christine noted, the transformative power of Industry 5.0 is rooted in [silicon engineering](#), where custom chip development drives the intelligence behind AI, IoT, and high-performance computing. The rise of AI-specific chips designed for machine learning is a key trend shaping Industry 5.0, enabling real-time decision-making and computational efficiency. At the same time, edge computing integration is gaining momentum, minimizing latency and enabling instant insights through custom silicon at the edge. Innovations in semiconductor manufacturing, like 3D chip stacking and neuromorphic computing, are pushing processing power while reducing energy consumption.



Key findings from the survey:

Custom chip development is considered critical for competitiveness, with 81% of organizations in Asia-Pacific, 74% in North America, and 67% in Europe recognizing its importance.

64%

While 64% still see Moore's Law as influential, the shift toward specialized custom silicon is clear.

73%

The CHIPS Act is a game changer, with 73% of North American companies expecting positive supply chain impacts.

90%

Heterogeneous integration will revolutionize computing, with 90% of organizations expecting a positive impact in five years.

Collaboration between hardware and software teams is essential, with 90% valuing it and 80% confident in their practices.

We now turn to how AI's insatiable demand for processing power is reshaping semiconductor architectures and fueling innovation, with Caligo Technologies providing insights into how this shift is propelling the race toward smarter, purpose-built hardware.



Anantha Kinnal
CEO, Calligo Technologies



AI-driven chip design and the ascendancy of custom silicon



Vinay N Hebballi
COO, Calligo Technologies



“Innovation in the semiconductor industry is accelerating, with AI-driven design and custom silicon leading the charge toward unprecedented computational efficiency.”

AI’s insatiable demand for compute power has forced a rethink of traditional architectures, driving the rise of custom silicon. Companies across the spectrum, from RISC-V startups to giants developing wafer-scale processors, are racing to build hardware explicitly tailored for AI workloads. The impact of this shift extends far beyond raw processing power—it is transforming the very way AI models are designed and trained.



Perhaps even more fascinating is AI's role in chip development itself. As AI models grow more sophisticated, they are beginning to contribute to the design process, generating novel architectures and optimizing performance in ways previously unimaginable.

The shifting power balance in semiconductors

Industry leaders agree that the semiconductor landscape has undergone a dramatic shift. No longer dominated by a select few, the field is now being reshaped by tech giants like Google and Amazon, developing their

own custom chips to meet the unique demands of their AI-centric ecosystems. By moving beyond traditional manufacturers, these companies are redefining control over performance, efficiency, and innovation. From our experience, legacy architectures often leverage just a fraction of available compute power—sometimes as little as 17%—highlighting a major inefficiency. Custom silicon is engineered to overcome this limitation, delivering tailored performance and unlocking the full potential of modern workloads.

The interplay of hardware and software

AI's hardware demands are redefining the relationship between silicon and software. Emerging designs are improving computational efficiency and closing the performance gaps that have long plagued AI workloads. With more intelligent electronic design automation (EDA) tools powered by AI, chip architectures are becoming more refined, optimizing power usage, thermal management, and transistor efficiency in ways never before possible.



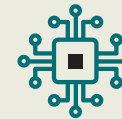
Trends in chip design and manufacturing

Smarter EDA tools are enabling the development of highly optimized silicon while reducing the number of engineers required for the process. At Calligo, we have experienced this firsthand. What once took large teams of specialists can now be achieved with lean, highly skilled groups leveraging AI to streamline design and fabrication.

Additionally, advancements in transistor packaging and spatial efficiency are extending Moore's Law in new ways. Companies focusing on consumer-grade ASICs are thriving by consolidating electronic functions into custom silicon solutions. In a world where AI and HPC demand the most advanced hardware, ASICs for mass-market applications still account for 70–80% of the semiconductor industry's revenue.

The global semiconductor race

Governments worldwide have recognized the strategic importance of semiconductor independence. China moved early, establishing a robust semiconductor ecosystem, while the U.S. CHIPS Act and India's national semiconductor initiative are now accelerating local manufacturing capabilities. These efforts are vital for economic and technological sovereignty and fuel innovation by providing startups with the capital and resources needed to develop next-generation silicon.



Advice for business leaders

Embrace Industry 5.0 by integrating hardware, software, automation, and human ingenuity. Those who adapt will lead a new era of intelligent, efficient, and ethical innovation.

AI and Machine Learning: Driving the intelligence of Industry 5.0



AI generated image

Artificial intelligence (AI) and machine learning (ML) form the cognitive backbone of Industry 5.0, enabling machines to learn, adapt, and optimize autonomously. These technologies are revolutionizing industrial operations by driving intelligent decision-making, predictive maintenance, and autonomous systems in manufacturing and supply chains.



Key findings:

AI and Machine Learning in Industry 5.0

Nearly all organizations are already leveraging AI-powered automation and report overwhelmingly positive impacts on business tasks and processes, including:

74%

Efficiency improvements:

74% of organizations report increased operational efficiency through AI-driven automation.

69%

Enhanced real-time decision-making:

69% of organizations cite improved decision-making capabilities.

64%

Boosted productivity:

64% report productivity gains, with efficiency also cited by 64%.



Organizations overwhelmingly recognize the transformative potential of AI, with 91% reporting improved efficiency and 85% seeing better real-time decision-making so far. 78% of organizations expect AI to revolutionize operational processes, while 74% believe it will enhance decision-making over the next five years.

AI's impact extends beyond internal efficiencies to broader business transformation:

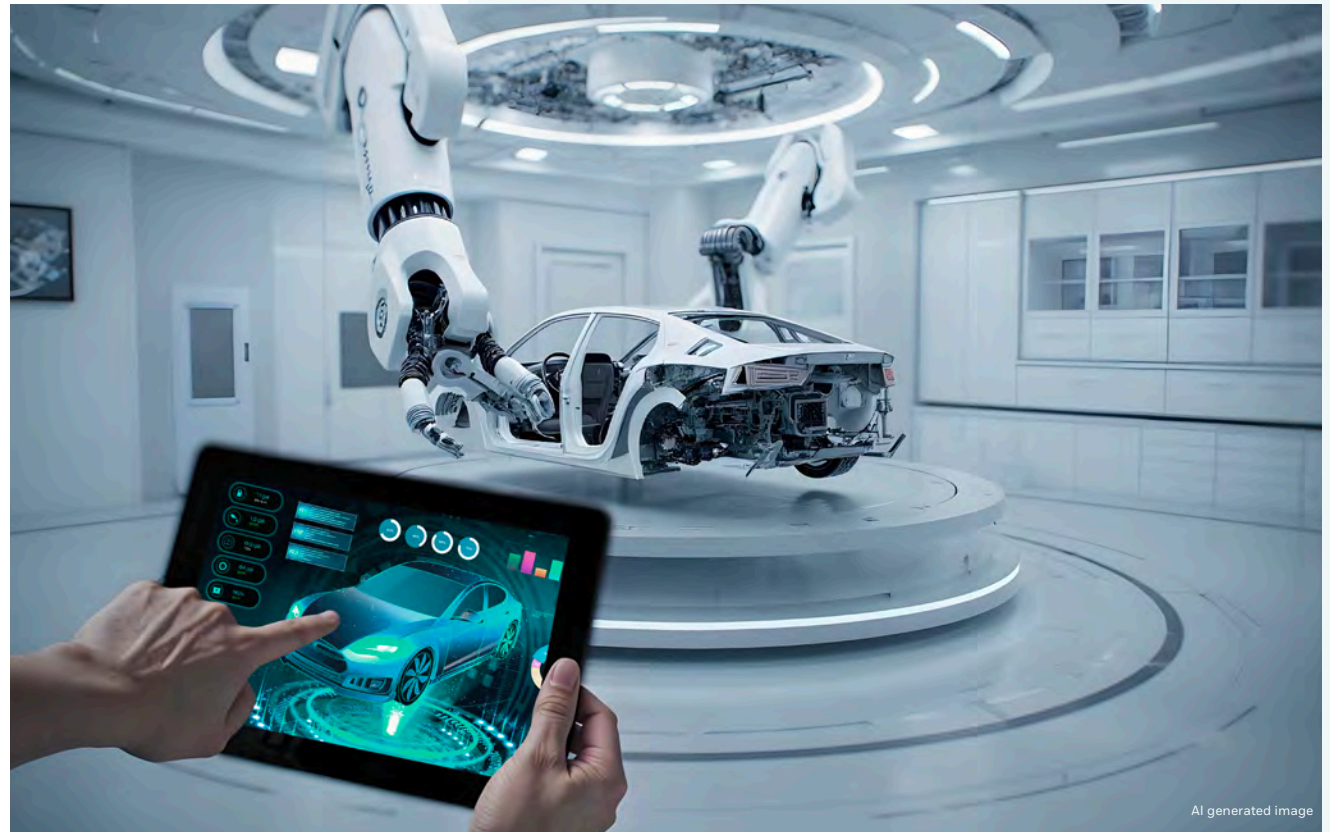
- Cost reduction and scalability: 82% of organizations expect AI to reduce costs and boost scalability.
- Customer-centric innovations: 72% anticipate more personalized and responsive customer engagement driven by AI insights.



Machine Learning: Turning data into actionable intelligence

Machine learning is playing a vital role in optimizing operations and maintenance strategies:

- Real-time optimization gains: 82% of organizations report significant operational efficiency and responsiveness improvements.
- Enhanced precision and accuracy: 76% experience heightened accuracy through data-driven insights.
- Predictive maintenance optimization: 71% have optimized maintenance schedules, 66% report improved prediction accuracy, and 65% have enabled more data-driven decisions.



AI generated image

Industry impact

Industry 5.0 is driving transformation across multiple sectors, fundamentally altering how industries operate and deliver value. A closer look:



Manufacturing:

- Smart factories equipped with predictive maintenance and AI-driven automation are setting new benchmarks for productivity and efficiency.
- Advanced robotics and digital twins optimize production lines and reduce downtime, creating agile and resilient manufacturing processes.

Healthcare:

- AI-powered diagnostics and robotic-assisted surgeries are enhancing patient care and surgical precision.
- Personalized medicine, driven by predictive analytics, offers tailored treatment plans that improve patient outcomes and reduce healthcare costs.

Supply chain and logistics:

- IoT-enabled tracking and autonomous delivery systems improve visibility and reduce logistical bottlenecks.
- Real-time demand forecasting enhances inventory management and strengthens supply chain resilience, minimizing disruptions.

Energy and sustainability:


- Smart grids and AI-driven energy optimization increase efficiency and reduce emissions.
- Sustainable material innovation supports greener production practices and aligns with global environmental goals.

Food:

- Intelligent automation, data-powered insights, and people-first strategies are reshaping the food industry—streamlining operations, minimizing waste, boosting safety standards, and creating more tailored experiences for consumers.
- Personalized nutrition, sustainable practices, and enhanced food safety through tech-enabled collaboration are transforming industry standards.

Automotive and mobility:

- Autonomous vehicles and connected car ecosystems are set to revolutionize transportation, offering enhanced safety and efficiency.
- Predictive maintenance powered by AI ensures vehicle reliability, minimizing breakdowns and extending lifespan.



Businesses across all sectors are poised for extraordinary opportunities for innovation, optimization, and future-proofing their operations. Proactive adoption is key; those who resist this evolution risk being left behind in a rapidly changing world.

However, the true transformative power of Industry 5.0 extends beyond efficiency gains. It lies in its capacity to deliver unprecedented precision and personalization, which is particularly crucial in sectors focused on human well-being. Nowhere is this more evident than in healthcare, where advancements are set to revolutionize patient outcomes and medical practices. In the next chapters, we will explore how Industry 5.0 reshapes healthcare and unlocks new possibilities for diagnosis, treatment, and patient care.

Spotlight: Industry 5.0 and Healthcare

PERSPECTIVE

Martin Gossling
Head of Commercial
Innovation at University
Hospital Southampton
(UHS)



“AI is breaking down barriers in healthcare, delivering high-quality care to remote regions and enabling real-time diagnostics at the edge.”

The future of AI, Robotics, and Edge Computing

Industry 5.0 is transforming healthcare through human-machine collaboration. At University Hospital Southampton, we leverage AI-powered robotics, edge computing, and data-driven systems to enhance patient care while maintaining human expertise. This approach boosts efficiency, accessibility, and proactive healthcare.



AI-powered robotics: Transforming patient care

AI-powered robots reduce physical strain and support non-invasive cardiac assessments, with potential, especially in remote settings like the Falkland Islands and cruise ships. By integrating AI, we deliver high-quality care to isolated regions, ensuring patients receive the support they need regardless of location.

From reactive to proactive healthcare

Our goal is to shift from reactive to proactive healthcare by 2050. Edge AI processes data locally, enabling real-time bio-signal analysis and early detection of health issues like heart attacks or strokes. This proactive approach ensures timely interventions and better patient outcomes. Building trust in AI systems through transparency and data reliability is crucial to success.

Training and trust: Preparing for AI in healthcare

The success of AI in healthcare relies on data quality and transparency. It is essential to train healthcare professionals to use AI tools and understand their decision-making processes. As AI handles routine tasks, professionals can focus on complex problem-solving and personalized care, enhancing efficiency and effectiveness.

Telecommunications: Backbone of AI-driven healthcare

Telecom networks must support higher bandwidth and real-time data processing to meet the growing demand for telehealth and AI-driven healthcare. Wearable devices and IoT sensors generate continuous health data, requiring robust telecom infrastructure to manage increased loads.



Silicon Engineering and Edge Computing: Real-time AI

Advancements in silicon engineering are critical for real-time AI, especially in energy-efficient chips for wearable devices and IoT sensors. Technologies like 3D ICs and die stacking increase computational density and reduce energy use, bringing AI closer to the point of care. Edge computing minimizes reliance on energy-hungry data centers, supporting sustainable practices while boosting AI efficiency.

AI in cancer research: Advancing oncology

AI is transforming cancer research by analyzing vast genomic datasets and enabling targeted therapies. At University Hospital Southampton, AI-driven activation of T-cells and macrophages shows promise in precision oncology, offering more personalized and effective treatments.



Advice for business leaders

To harness Industry 5.0 in healthcare, leaders must build trust in AI systems, prioritize data security, and embrace edge computing for real-time health monitoring. Transparency and robust security measures are essential to gaining professional and patient confidence, paving the way for AI-driven healthcare innovation.

Spotlight: Industry 5.0 and Healthcare

PERSPECTIVE

Lance Kenworthy
Chief Digital Officer,
Tunstall Healthcare



“By integrating AI, IoT, and advanced analytics, Healthcare 5.0 unlocks new opportunities for predictive and citizen empowered healthcare.”

The shift to proactive and predictive care

The Healthcare 5.0 evolution goes beyond smarter technology to prioritize human-centric care, where data-driven insights empower individuals and healthcare providers. At Tunstall, we aim to enable people to have the freedom to live independently in their homes for as long as possible, even as they age or manage chronic conditions. By leveraging IoT-enabled services, AI-driven analytics, and proactive care models, we are shifting from reactive to predictive healthcare, fundamentally redefining patient well-being.





From reactive to proactive: The power of data and AI

For decades, healthcare has primarily been reactive—responding to emergencies and treating conditions only after symptoms escalate. Industry 5.0 is changing this paradigm by embedding sensors and IoT devices in homes to monitor daily behaviors, vital signs, and environmental factors in real time. Machine learning models continuously analyze this data to detect anomalies that could signal health risks before they become critical.

Consider a simple yet impactful scenario: a sudden cold snap. If the system detects that an older adult's home temperature is too low—alongside reduced movement and food intake—it can prompt intervention before conditions like pneumonia develop. This proactive, data-driven approach defines Healthcare 5.0, enabling early interventions that save lives and reduce emergency admissions.

The convergence of technologies: Unlocking new opportunities

Integrating AI, IoT, and advanced analytics is opening new doors in healthcare. AI is no longer limited to research; it now actively supports healthier lifestyles by identifying patterns in daily routines—such as fluctuations in blood pressure, irregular activity levels, or changes in sleep patterns. These insights prompt individuals to make small, impactful changes, putting greater health control in their own hands.



Digital Twins: The future of personalized healthcare

One of the most promising advancements in Healthcare 5.0 is the concept of digital twins—digital replicas of individuals continuously updated with real-time health data. Though still emerging, digital twins could simulate the effects of lifestyle changes and medication adjustments or predict potential health risks based on past behaviors. This level of personalization moves healthcare beyond generic treatment models, enabling precise, individualized care.

Robotics, automation, and custom silicon: Scaling healthcare innovation

Robotics and automation are streamlining processes in manufacturing, software testing, and administration, boosting efficiency and quality. In software development, automation ensures faster deployment of critical healthcare applications.

Advice for business leaders

For business leaders, embracing Industry 5.0 requires a fundamental shift in the way we currently work. Open-mindedness and encouraging internal and external collaboration across organizations, sectors, and countries are essential to sharing best practices and addressing common challenges like skill gaps and better supporting the needs of an increasingly aging population. Above all, prioritizing person-centric care and breaking down silos will ensure healthcare systems evolve to meet future needs.

Sensors and IoT: The nervous system of Industry 5.0



Sensors and IoT form the sensory network of Industry 5.0, seamlessly integrating physical assets with dynamic digital ecosystems. These technologies generate real-time data for monitoring, diagnostics, and automation, enabling predictive maintenance and stringent quality control while minimizing downtime. IoT-powered supply chain visibility and logistics optimization delivers unprecedented transparency and control, while energy-efficient IoT solutions drive the evolution of smart cities and industrial applications.



Key findings:

- Safety and security systems (68%): IoT enhances workplace safety and protects assets.
- Quality control (60%): Real-time monitoring ensures consistency and high standards.
- Predictive maintenance (57%): Data-driven insights minimize unplanned downtime.
- Asset tracking (54%): Efficient inventory and equipment management.
- Customer engagement (52%): Real-time data enables personalized interactions.

Challenges:

- Data privacy (53%) and network security (52%) remain top concerns.
- Device authentication (48%) and firmware vulnerabilities (44%) require continuous monitoring.

Emerging innovations:

68%

Miniaturization and edge computing: Compact sensors enhance safety (68%) and real-time insights (61%).

64%

Customization (64%): Tailored, localized solutions through edge computing.

As Industry 5.0 evolves, **sensors and IoT** remain pivotal, enabling agile, data-driven decision-making while addressing security and data management challenges.

Fram Akiki

President, Joun Technologies



“Industry 5.0 is redefining semiconductor innovation through convergence—merging hardware, software, AI, and connectivity to drive unparalleled efficiency and resilience.”

The power of parallelism and the rise of Digital Twins in Industry 5.0

In my years working in semiconductor innovation, one thing has become clear—Industry 5.0 is about convergence. It's about the fusion of hardware, software, AI, and connectivity, all working in sync to drive efficiency, resilience, and sustainability. The traditional ways of designing and manufacturing technology are evolving at an unprecedented pace, and at the heart of this transformation are two critical advancements: parallelism in design and the rise of digital twins.





Parallelism: The shift left to simulation-driven design

For decades, chip development followed a linear path—design, test, simulate, and manufacture. While effective in its time, that process doesn't cut it in the age of AI, automation, and rapidly evolving computing needs. The industry is now embracing parallelism, a shift left that allows multiple aspects of the design and manufacturing process to happen earlier and in parallel.

Simulation-driven design enables engineers to test and refine chip architectures long before they physically exist. This shift left reduces risk and accelerates time-to-market. It's now possible for system-level software developers to begin their work before the final chip is even produced, ensuring seamless hardware-software integration from the outset.

Beyond efficiency, software-defined silicon is reshaping the industry. Instead of relying on constant hardware iterations, we are extending chip lifecycles through software updates. This approach is critical, especially given semiconductor production's immense cost and complexity. A well-architected chip, enhanced with continuous software refinements, delivers more value over time—without expensive redesigns.



The rise of Digital Twins: Compute power meets connectivity

Another game-changing trend in Industry 5.0 is the proliferation of digital twins. The ability to create highly accurate virtual replicas of physical systems—whether a factory floor, an autonomous vehicle, or an entire semiconductor fab—is revolutionizing how we design, optimize, and manage technology.

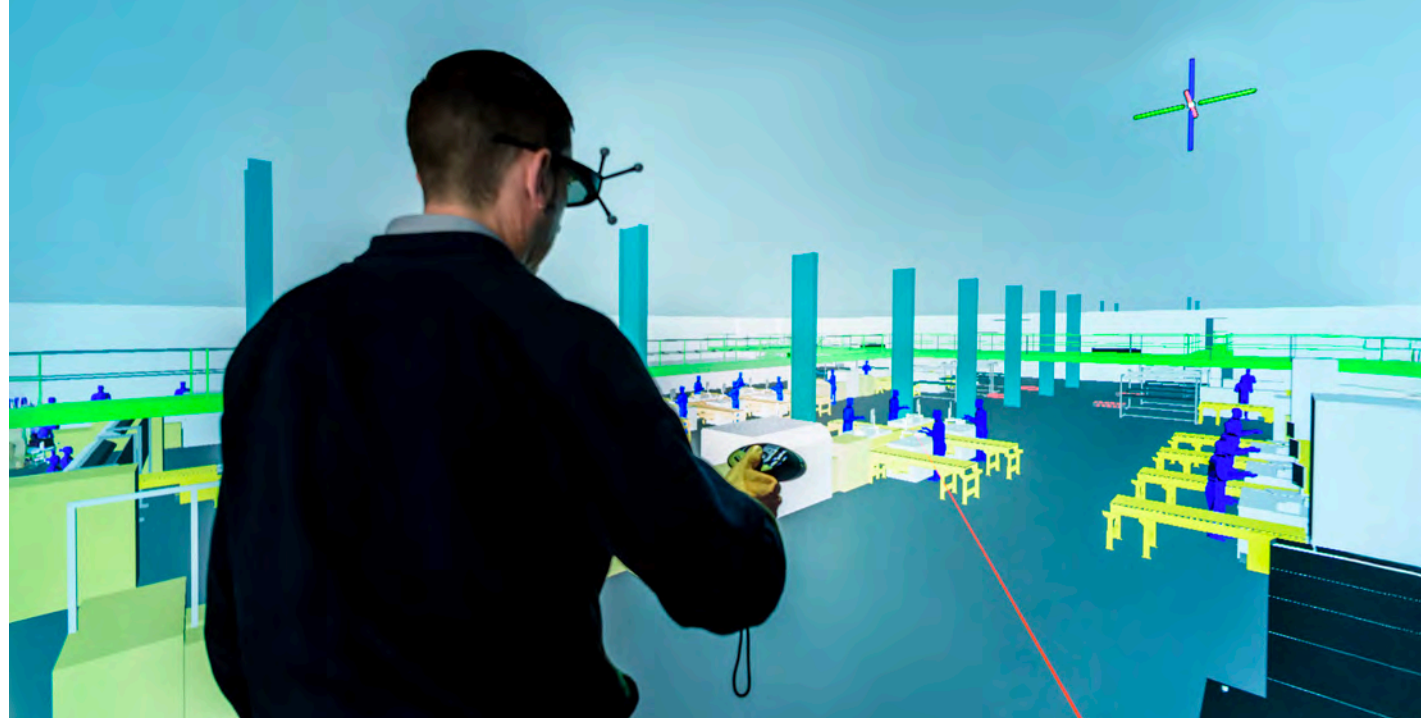
Two key enablers have made digital twins practical at scale:

1. **Unprecedented Compute Power:** Cloud computing now provides nearly limitless processing capabilities, allowing real-time simulations and predictive analytics at an unimaginable scale.
2. **Seamless Connectivity:** With 5G and 6G, we now have the infrastructure to support real-time data transfer between digital twins and their physical counterparts. For example, the ultra-low latency of 5G enables applications like real-time accident avoidance in automobiles, an impossible advancement in the 4G era.

Digital twins are particularly transformative in semiconductor manufacturing. By simulating fabrication processes, they help optimize yield, energy consumption, and production efficiency, addressing some of the most pressing challenges in the industry. The ability to predict failures before they happen is reshaping how fabs operate, reducing waste, and improving overall output.

Advice for business leaders

The convergence of AI, IoT, and robotics is ushering in a new era of dynamic value systems. Those who embrace parallelism and leverage digital twins will lead this transformation. Those who resist will find themselves struggling to keep up.



Digital Twins: Virtual replicas driving Industry 5.0

As Fram pointed out, [digital twins](#) are revolutionizing industrial operations by creating virtual replicas of physical assets, enabling real-time simulation, optimization, and predictive analysis. By integrating AI, IoT, and robotics, digital twins offer dynamic modeling, monitoring, and management of complex systems, significantly enhancing operational efficiency and reducing downtime.



Key findings:

Digital twin adoption is accelerating, with one-third of organizations reporting advanced or mature implementations. Although 28% of organizations do not currently utilize digital twins, those that do leverage them primarily for:

- Optimization (75%): Enhancing efficiency through real-time simulations and predictive analysis.

- Predictive maintenance (60%): Proactively addressing maintenance needs to reduce downtime.
- Furthermore, 72% plan to expand digital twin applications to new areas, including:
- Maintenance and operations (68%): Improving asset reliability through predictive analytics.
- Sustainability and environmental management (59%): Reducing environmental impact via data-driven insights.

72%

Robotics: Increased automation (72%) and optimized performance (62%).

Integration with emerging technologies:

68%

AI: Real-time monitoring and control (68%), enhanced decision-making (60%).

65%

IoT: Increased automation (65%) and real-time monitoring (62%).

As adoption grows, strategic integration with AI, IoT, and robotics will unlock even greater operational optimization and innovation potential.

Spotlight: Industry 5.0 and the food industry

PERSPECTIVE

Juan Pedro Florido
COO of EIPozo Alimentación



Forging the
future of food
through
Industry 5.0
leadership

“Industry 5.0 in food production blends innovation with responsibility—where AI, automation, and sustainability work harmoniously to drive efficiency without compromising ethics.”

At EIPozo Alimentación, we are actively shaping the trajectory of Industry 5.0 within the food industry. Our vision transcends growth, focusing on excellence through a harmonious blend of innovation, efficiency, sustainability, and unwavering ethical commitment. This transformation is driven by the strategic integration of innovative technologies, including automation, artificial intelligence (AI), and real-time control, all deeply rooted in our commitment to quality.



Technology as an enabler of excellence:

Robotic systems on our processing and packaging lines ensure unparalleled speed, consistency, and minimized production times. AI-driven logistics optimization has achieved a remarkable 20% reduction in transport needs and delivery times, enhancing our vertically integrated model from livestock management to distribution.

Beyond operational efficiency, Industry 5.0 is a catalyst for sustainability. AI-powered processes optimize energy consumption, while IoT sensors provide real-time insights into livestock health, ensuring both productivity and ethical responsibility. Our anaerobic digesters convert waste into biogas, significantly reducing greenhouse gas emissions and our reliance on fossil fuels.

We recognize that technological advancement presents challenges. The transition to automation requires substantial workforce training, a challenge we address through experimental initiatives like [LAB19](#), developed in partnership with public universities. While the initial investment in advanced technologies is significant, the long-term gains in efficiency and sustainability make it a strategic imperative.

Sustainability and ethical responsibility are integral to our DNA. Our strategy provides a decisive competitive edge. Automation, AI, and IoT ensure real-time quality control, enhance operational efficiency, and reduce costs without compromising excellence. Our sustainability efforts have earned us the prestigious Lean&Green second-star certification, recognizing a CO2 reduction of over 20%.



Advice for business leaders

As business leaders, we must recognize that the future of the food industry hinges on a harmonious balance between technological excellence and human-centric values. To stay ahead, we need to embrace innovative solutions while remaining committed to our ethical and environmental responsibilities. Investing in AI-driven demand forecasting, leveraging voice AI for seamless data entry, and implementing advanced automation are areas where we can make a significant impact. These technologies improve efficiency and empower our workforce, allowing employees to focus on more meaningful, creative tasks while technology handles routine processes.

Stay curious, stay agile, and, above all, stay committed to putting people first—because that’s the essence of Industry 5.



Robotics: The physical manifestation of Industry 5.0

Juan's perspective highlights how robotics is at the cutting edge of Industry 5.0, exemplifying the fusion of advanced technologies to boost productivity, efficiency, and human collaboration. Unlike previous industrial revolutions focused solely on automation, Industry 5.0 emphasizes collaborative robots (cobots) and autonomous systems designed to enhance—not replace—human capabilities.



The rise of collaborative robots (Cobots)

Cobots are transforming industries by working safely alongside humans and handling repetitive or hazardous tasks while allowing employees to focus on more complex and creative work. Despite their potential, adoption remains limited, with only about half of organizations using cobots. A significant challenge is workforce readiness—46% of organizations do not provide specific training for working with cobots. Of those that do, training often lacks depth:

- Basic robotics safety and handling (35%)
- Customized training based on departmental needs (32%)
- Human-machine interaction safety (32%)

Autonomous robots: From inspection to logistics

Autonomous robots are becoming essential for inspection, logistics, and operational tasks, improving accuracy and safety.

Key applications include:

39%

Inspection and Quality Control (39%): Automating inspections reduces human error and ensures consistency.

37%

Material Handling and Logistics (37%): Streamlining warehouse operations boosts efficiency.

36%

Assembly Line Operations (36%): Increasing production speed while reducing workplace injuries.

However, ethical concerns persist, with 43% of organizations citing safety risks in human-robot interactions and 43% worried about bias in decision-making, especially in quality and safety assessments.

Balancing innovation and responsibility

Maximizing the potential of cobots and autonomous robots requires addressing training gaps, ethical concerns, and safety protocols. A robust robotics strategy should include skill development and clear ethical guidelines, fostering human-centric innovation while maintaining safety and precision.

Key challenges and considerations for Industry 5.0 adoption

Industry 5.0 holds the potential to revolutionize various sectors through advanced automation, AI integration, and human-machine collaboration. However, the journey toward widespread adoption is riddled with challenges that demand strategic foresight, agile transformation, and robust security measures.



Strategic transformation challenges

One of the most significant risks for businesses lies in the dual challenge of adopting new technologies quickly while avoiding resource overextension. While 75% of organizations feel well-prepared to adapt their business models to meet Industry 5.0 demands, the risk of moving too fast without a clear strategy can lead to inefficiencies and fragmented implementations. Leaders must maintain a strategic focus—prioritizing areas where AI and automation will drive the most impact without diluting efforts across too many initiatives.

Geopolitical and supply chain vulnerabilities

The geopolitical landscape significantly impacts the semiconductor industry, with access to critical raw materials like gallium and germanium now a top concern. Supply chain vulnerabilities and shifting trade policies demand more resilient and diversified sourcing strategies. The Chips and Science Act is a positive step toward securing semiconductor manufacturing capabilities in the United States, but questions remain about whether isolationist approaches can sustain long-term innovation in a globally interconnected industry.

Ethical and social considerations

As AI-driven systems assume more critical decision-making roles, ensuring transparency, explainability, and accountability becomes essential. Nearly half of organizations (50%) are concerned about ethical implications, particularly data privacy and AI fairness. 48% have implemented transparency measures in AI decision-making to address this, while 45% regularly update their ethical policies. Ethics training is prioritized by 85% of organizations, while 69% conduct risk assessments to mitigate AI bias and data privacy risks.

In healthcare, the ethical use of AI becomes even more pressing as connected devices proliferate. Blockchain technology offers a promising avenue for ensuring data integrity and enhancing transparency. Healthcare leaders must proactively address these challenges to foster trust and security in AI-driven healthcare systems.

Sustainability and environmental responsibility

Industry 5.0 emphasizes sustainable innovation, but the environmental impact of increased data processing remains a critical concern. Edge computing can help minimize energy consumption by processing data locally, reducing the load on large data centers. This not only improves the efficiency of AI systems but also supports sustainable healthcare practices and responsible industrial operations.

Security challenges in a connected era

With Industry 5.0 driving interconnected, AI-powered operations, robust cybersecurity is non-negotiable. Real-time data processing introduces new attack vectors, and maintaining operational integrity requires comprehensive security strategies. Most organizations (75%) recognize the critical importance of cybersecurity, and 77% maintain dedicated security teams to manage risks. Key measures include

access control (56%), multi-factor authentication (63%), and continuous employee training (54%). Yet, challenges persist. Managing data volume and complexity (51%) and countering evolving cyber threats (49%) remain major pain points. Additionally, regulatory compliance remains a hurdle for 45% of organizations, emphasizing the need for updated security protocols and resilient digital ecosystems.

Talent and workforce evolution

The workforce landscape is transforming as AI and automation become integral to operations. In software development, AI has already reduced human-written code by nearly 40%, while hardware roles are also evolving to meet the demands of intelligent systems. Despite this, human expertise remains essential—especially in engineering and maintenance roles where collaboration with automated systems is increasingly important.

The semiconductor sector faces a critical talent shortage, exacerbated by the rapid shift toward proprietary chip development among tech giants like Apple and Google. Traditional chipmakers must redefine their value propositions to remain competitive, focusing on agility, innovation, and enhanced skill sets. Upskilling initiatives are vital, as intelligent automation demands new competencies that balance human creativity with machine precision.

In the next chapter, we will explore how targeted learning and development initiatives are empowering workers to thrive in an AI-driven economy, ensuring that human potential remains at the forefront of Industry 5.0.

Dr. Hari Narayanan
CEO of the Penang Skills
Development Centre (PSDC)



“AI isn't replacing jobs—it's redefining them. Investing in reskilling through experiential learning and AI-powered tools equips the workforce with practical skills to thrive in an AI-driven future.”

Bridging the talent gap through learning and development

Despite the fears of AI replacing jobs, human intelligence will always remain a step ahead. AI is a tool that enhances human capabilities rather than rendering them obsolete. As AI has a transformative impact on organizations and society at large, it is imperative for governments and organizations to proactively address the talent needs in the AI age through structured upskilling and reskilling initiatives.



The Malaysian government has identified over 625,000 jobs that AI could impact, but it is also actively investing in new employment opportunities. Through strategic interventions led by the National AI Office, the focus is on equipping the workforce with the skills needed to thrive in an AI-driven economy.

Our approach to workforce development emphasizes role-based training interventions. We collaborate with the industry to provide training programs integrating theoretical and practical components. By encouraging local businesses to move up the AI value chain, we ensure that AI adoption is not just among multi-national companies but across the ecosystem.

Integrating AI, IoT, and semiconductors into training

At PSDC, our training programs are structured around the technologies that define Industry 5.0—IoT, advanced semiconductors, and AI. We provide hands-on experience to ensure that learners are not just familiar with these innovations but are adept at implementing them in real-world scenarios. Through partnerships with AI Singapore, we are leveraging AI assessment tools to tailor training interventions for businesses, helping them integrate AI into their operations seamlessly.

Beyond traditional training, we have also retrofitted our labs with IoT devices and sensors, enabling practical learning experiences. By capturing and analyzing data in real time, we expose students and trainees to real-world scenarios. This emphasis on experiential learning ensures that our workforce remains adaptive and future-ready.



AI-driven future of learning and workforce development

While digital twin technology has yet to be widely incorporated into training programs, we foresee a future where it plays a critical role in skill development. The future of learning in Industry 5.0 will be a blend of hands-on experience, instructor-led training, and AI-powered self-learning tools. Industry-relevant challenges will continue to shape our training methodologies, ensuring that students and professionals have skills that align with evolving technological landscapes.

Advice for business leaders

Business leaders must take a proactive approach to AI adoption. Cost and competitiveness will remain primary considerations, but AI's transformative potential cannot be ignored. Investing in talent development through role-based training interventions will ensure a smooth transition to an AI-powered future. Many governments are offering incentives to support AI adoption, and businesses should take full advantage of these opportunities to offset costs and accelerate innovation. Finally, adopting a hybrid learning model that combines instructor-led training with AI-driven self-learning will prepare the workforce to thrive in an ever-evolving technological landscape.

Kuruvilla Mathew

Chief Innovation Architect, UST



“Industry 5.0 isn't just about smarter tech—it's about human-centric innovation, where intuitive interfaces and AI-driven insights make technology feel invisible, yet indispensable.”

Navigating the human-centric shift of Industry 5.0





I see the shift from Industry 4.0 to 5.0 as an evolution from system-to-system interactions to human-system interactions. Industry 4.0 revolutionized manufacturing and automation by integrating machine learning and dynamic object detection. But Industry 5.0 goes beyond that—it breaks down the barriers between humans and machines. We’ve moved from typing on keyboards to using speech recognition, from manual processes to intuitive interfaces that understand human intent. This is the era of digital transparency—where technology becomes invisible yet omnipresent, much like how Uber and Lyft transformed transportation without requiring users to understand the underlying technology.

One of the most fascinating aspects of this transformation is how AI enables us to articulate complex data in human-understandable terms. Take ChatGPT, for example—it’s not just a chatbot. It’s a tool that eliminates the need for extensive research by summarizing and presenting information concisely. This, to me, is the fundamental shift in Industry 5.0: making technology so intuitive that we don’t consciously think about it anymore. Just as we don’t actively think about GPS when navigating, we won’t believe in AI-driven decision-making—it will simply be part of how we work and interact.

I like to think of this convergence of technologies as the “primordial soup of digital transformation.” We’re witnessing the merger of AI, digital twins, additive manufacturing, and next-generation sensing technologies, giving rise to entirely new applications and industries. But, of course, this evolution comes with its own set of challenges. The ability to 3D print complex structures, for example, has massive potential in manufacturing, but it also raises concerns about misuse—like the creation of untraceable weapons. Similarly, hardware advancements must keep pace with software innovation. Miniaturization, energy efficiency, and heat dissipation are critical challenges that we must address to ensure continued progress.

We’re already seeing this shift across industries. Microelectromechanical sensors (MEMS) enable self-aware vehicles like Teslas and Rivians in the automotive sector. In telecommunications, companies like T-Mobile, Verizon, and AT&T are exploring the potential of Industry 5.0. At UST, we’re focusing on AI-driven domain specialization in healthcare, retail, supply chain, and semiconductor industries. We’re investing in digital twins, additive manufacturing, computer vision, audio analysis, and future sensing technologies—all driven by AI. The goal isn’t just to develop new capabilities but to reshape business models and the job market entirely.

The biggest challenge in this transition isn’t the technology itself—it’s the mindset shift required to move from commodity skills to domain expertise. Historically, IT was built around general-purpose skills like Java and Oracle. However, the future demands specialists who can apply AI, digital twins, and advanced analytics to specific industries. Companies that don’t adapt will inevitably fall behind those that embrace this rapid innovation cycle. Consumers today expect faster, smarter, and more intuitive experiences—much like how we transitioned from cable to streaming services. The need for agility has never been more critical.



AI generated image

Conclusion: Navigating the crossroads of innovation and responsibility in Industry 5.0

As this report has demonstrated, the convergence of Industry 5.0 technologies presents a pivotal moment for businesses, demanding a crucial choice: embrace innovation and thrive or resist change and risk obsolescence.



Encouragingly, our survey reveals that an impressive 75% of organizations believe they are well-prepared to adapt their business models to meet the demands of Industry 5.0. Over the next five years, organizations anticipate significant enhancements in operational efficiency (76%) and transformative shifts in customer interactions and experiences (66%).

A heightened focus on security is also evident, with organizations prioritizing advanced cybersecurity frameworks to

mitigate emerging risks. Furthermore, most organizations have already implemented ethical frameworks or guidelines for AI and automation (90%), with a strong emphasis on privacy (79%), transparency (74%), and safety/security (73%). This commitment to ethical practices is further reinforced by the fact that 85% of organizations prioritize ethical training, and 69% conduct ethical risk assessments to proactively address AI bias and data privacy concerns.

The rise of **intelligent automation** necessitates a fundamental shift in workforce development, with companies investing in developing skills that effectively balance human creativity with machine precision. This proactive approach is crucial in fostering a workforce prepared for the hybrid human-machine collaboration that defines the future of work.

Moreover, AI-driven optimization is emerging as a powerful tool for achieving sustainability goals. Businesses are increasingly leveraging these technologies to reduce waste, minimize energy consumption, and lower their carbon footprints, demonstrating a growing commitment to responsible and resilient operations. Smart technologies are being used to maintain efficiency while simultaneously minimizing environmental impact.

Strategic imperatives for Industry 5.0 success:

To effectively navigate the challenges and opportunities of Industry 5.0 adoption, business leaders must prioritize the following strategic imperatives:

- **Prioritize ethical governance and transparent AI decision-making:** Building trust and ensuring responsible AI implementation requires a commitment to ethical principles and transparent processes.
- **Develop a flexible and skilled workforce capable of collaborating with intelligent systems:** Investing in upskilling and reskilling initiatives is essential to prepare the workforce for the collaborative human-machine environment of Industry 5.0.
- **Adopt sustainable practices that reduce energy consumption and minimize environmental impacts:** Integrating sustainability into core business strategies is crucial for long-term resilience and environmental responsibility.
- **Enhance security frameworks to protect against emerging threats and data vulnerabilities:** Robust cybersecurity measures are paramount to safeguarding data, operations, and trust in an increasingly connected, AI-driven world.

By effectively balancing innovation with responsibility, organizations can fully unlock the transformative potential of Industry 5.0 while simultaneously safeguarding trust, ensuring security, and fostering long-term resilience. This dual focus is essential for navigating the complexities of this new era and achieving sustainable success.

About UST

Since 1999, UST has worked with the world's best companies to make a powerful impact through transformation. Powered by technology, inspired by people, and led by our purpose, we partner with our clients from design to operation. Our digital solutions, proprietary platforms, engineering, R&D, products, and innovation ecosystem turn core challenges into impactful, disruptive solutions. With deep industry knowledge and a future-ready mindset, we infuse expertise, innovation, and agility into our clients' organizations—delivering measurable value and positive, lasting change for them, their customers, and communities worldwide. Together, with 30,000+ employees in 30+ countries, we build for boundless impact—touching billions of lives in the process.

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Together,
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