



Powering the Future of Industrial Technology

An Overview of the Megatrends Shaping the Future of Smart Solutions

Introduction

In today's rapidly evolving industrial market, electromechanical systems drive technological advancements. Benchmark's Center of Excellence for Electromechanical Systems in Almelo is helping to spearhead this transformative change and drive innovation. This whitepaper outlines exciting megatrends we see shaping the future of the industrial market.

What Forces Drive Advancements in the Industrial Market?

To better understand the momentum behind these eight megatrends, we must first understand the contextual forces propelling them forward.

Climate Change and the Scarcity of Resources

Growing concerns about climate change and resource scarcity urge societies, governments, and industries to seek sustainable alternatives, particularly transitioning from fossil fuels to cleaner energy sources and electric power. Awareness of how climate change and resource scarcity can intensify social inequalities drives investments in climate change mitigation, recognizing the potential strain on workforces and operational challenges.

Technology Breakthroughs

In the coming 5 to 10 years, emerging technologies—including artificial intelligence (AI), robotics, energy storage, DNA sequencing, blockchain, and materials science—are poised to create substantial value, triggering increased demand across industries and regions.

Changing Demographics and Shifting Global Economic Power

The global landscape is profoundly transforming as more nation-states vie for influence, leading to new areas of interest and alliances. As geostrategic fractures evolve, political, economic, and social consequences will be far-reaching. To secure leadership positions in emerging clean industries, nations recognize the economic and geopolitical benefits of early adoption, leading to the need for investment in electrification and low-carbon alternatives to tackle multifaceted global challenges. Additionally, concerns about future worker shortages in some nations due to declining populations are rising.

8 Megatrends in the Industrial Market

As Benchmark's Center of Excellence for Electromechanical Systems, we act as a hub of innovation, driving advancements in smart manufacturing, digitalization, and energy efficiency. We are setting new benchmarks for excellence in electromechanical engineering through strategic partnerships, research collaborations, and a forward-thinking approach. In that vein, we describe below the eight influential megatrends driving advancements in the industrial market. This megatrend overview was generated by combining several megatrend studies that were conducted by well-known global consultancy firms and non-governmental organizations (NGOs).^{1,2,3}

Megatrend #1: Electrification and Clean Energy Revolution

The world is rapidly transitioning towards electrification and decarbonization across various industries. The increasing adoption of electric vehicles and renewable energy technologies drives this change. Governments

and major industry players are investing heavily in developing electric vehicles and infrastructure, leading to a shift towards clean energy alternatives. Breakthroughs in battery technology, grid management, and sector coupling are accelerating the integration of renewable sources, leading to significant reductions in carbon emissions. The transition towards a more sustainable future is not limited to transportation and energy sectors but extends to other domains such as manufacturing and construction.

**Benchmark
Almelo embraces
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Innovative technology combined with a commitment to reducing carbon footprints reshapes industries and fosters a more environmentally conscious future. Renewable energy technologies and energy storage solutions are essential in transitioning towards a habitable planet while remaining cost-effective. Sensing, communication, IoT, intelligent control, AI, and machine learning are critical in achieving optimal sector coupling. Electromechanical systems are also essential in harnessing the potential of hydrogen as a clean energy source. Countries worldwide are investing in developing hydrogen infrastructural backbone pipelines, transfer locations, and high-pressure storage solutions, making it a \$700 billion opportunity that will need many new smart controls, sensors, and systems.

Megatrend #2: High-Tech Robotification and Automation in Industry and Agriculture—Strengthening Safety and Efficiency

Industrial robotics will make daily jobs safer, more accessible, more efficient, and ideally, even cleaner. Consider inspection and maintenance of high-voltage power lines that can be made safer and more accessible with the use of smart drone robots or farming made more efficient with agricultural robots. Not only do sensor fusion, machine learning, and



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smart motor control systems steer maximum degrees of freedom, but compactness, latency, and vision solutions also play a key role.

Autonomous modularity is gaining popularity in the more stationary production lines due to its flexibility and scalability. Physical artificial intelligence (AI) is advancing thanks to the development of robotic algorithms for perception, cognition, navigation, and machine learning capabilities. These advancements drive the realization of precision-alignment solutions within automation and robotics and ensure seamless integration of modules, optimizing user experience and reducing downtime.

Megatrend #3: AI and Digital Twinning—Accelerated Innovation

Digital twinning revolutionizes how industrial systems are designed, simulated, and optimized. By creating virtual replicas of physical systems and using AI engineers, we can identify inefficiencies, predict performance, and implement improvements with greater precision. By increasing computing power, AI will help solve some of our most complex challenges.

The development of modern and advanced information technology — such as big data, AI, the Internet of Things, (IoT) edge computing, and model-based system engineering —has promoted the transformation of traditional development and production toward a more intelligent and sustainable one that enables more autonomy and active self-optimization.

Megatrend #4: Increase of Additive Manufacturing (AM) —Unlocking Innovative and Sustainable Solutions

The significance of electromechanical systems is increasingly evident in the advances made in 3D printing. Initially used for rapid prototyping, 3D printing has expanded to include the entire product line through additive manufacturing (AM). This progression is paving the way for the next significant shift, automated AM, tailored for individualized production. Automation significantly reduces costs.

By emphasizing the significance of electromechanical systems and establishing dedicated 3D printing hubs, businesses can harness the full potential of AM, streamlining production processes and minimizing waste. This enables products to be introduced to the market much faster, offering companies a competitive advantage. With the emergence of 3D metal printing, AM technologies, and Wire and Arc AM (WAAM), product design and production processes have been enhanced. High-tech systems benefit from unparalleled design freedom and material versatility, resulting in lightweight, complex structures that reduce waste and enable new performance levels.

Megatrend #5: Augmented Advanced Human-Machine Interaction—Transforming the User Experience

Augmented reality (AR) and virtual reality (VR) technologies enhance the user experience in



industrial settings. From assembly-line operations to maintenance and troubleshooting tasks, AR/VR solutions provide interactive guidance, real-time data visualization, and remote assistance, boosting efficiency and reducing errors to accelerate Industry 4.0, metaverse applications, maintenance, and training. With the further miniaturization of electronics and faster 5G and 6G communication technologies, lightweight and robust AR hardware is within sight.

Megatrend #6: Next-Level Secure Connectivity, Sensing, Measurement, and Control

The megatrend of new connectivity encompasses optimizations and standards such as Single Pair Ethernet (SPE) and Advanced Physical Layer (APL), streamlining data transmission. 5G's rapid evolution and the anticipation of 6G promise faster, more interconnected networks. This trend fuels the IoT revolution, enabling widespread smart device integration. Time-sensitive networking (TSN) ensures reliable real-time data delivery while open controls enhance interoperability, propelling us toward a future of efficient and innovative connectivity. Smart cities exemplify the peak of secure connectivity, harnessing advanced sensing, precise measurement, and comprehensive control throughout urban landscapes.

But all this enhanced connectivity needs to be executed securely. Protecting intellectual property, preserving business ecosystems, and building 100% reliable systems for guaranteed operation data protection and privacy conformity are all becoming more essential.

Companies are looking for options to protect their embedded hardware in the most cost-effective way. Models, protocols, and technologies that can support this are increasingly being developed, including:

- Gaia-X
- Trust Architecture
- Security Scan
- Blockchain Security Solutions
- Zero Trust Security.

Megatrend #7: Smart Solutions for Building a Circular Economy

We need to think in circular systems and phase out the conventional linear thinking we are used to. In our material chain, we must find the best methods to retain, reuse, refurbish, remanufacture, and recycle. The first steps can focus on using bio-based plastics, but more advanced material design choices can be made after conducting a Life Cycle Analysis (LCA).

The industry market is critical in implementing a closed-loop global material system. Manufacturing processes, enabling efficient material recycling, waste reduction, and energy recovery need to be reinvented. Design processes will be guided by new standards that require design for repairability, refurbishing, upcycling, efficient disassembly, material separation, and waste and recycling technology. Circular factories will become more decentralized and aim to minimize waste and maximize resource utilization. Building a decentralized circular economy requires the growth of



other manufacturing processes, such as new additive manufacturing technologies. Adopting circular supply chain models allows for the design of business strategies that prioritize repair over waste generation.

Megatrend #8: Model-Based Engineering of Complex Systems by Multidisciplinary Teams

Our eighth megatrend serves as the overarching umbrella that encompasses and facilitates the emergence of all previously mentioned trends.

The advancement of technology drives the development of intricate high-tech machines, incorporating advanced elements like ultra-high roboticization, ultra-high vacuum systems, sensor fusion, precision alignment, and innovative materials. Systems can be controlled in a multi-model way using multiple touchscreen projections, head-up displays, or other AR solutions. There are now machines that act as advanced power distribution cabinets and various complex machine conditioning racks. In multiple applications (including applications within the semiconductor industry), we will see growth in hydrogen systems, green tech, climate tech, data centers, and advancing aerospace. These high-tech systems require multi-physics teams trained to work within a multidisciplinary team approach and use model-based engineering and simulation to design innovative systems most efficiently.

Digital Transformation in Engineering and Manufacturing

Benchmark Almelo serves as a Center of Excellence for Electromechanical Systems, driving innovation and delivering advanced solutions. We collaborate closely with leading research institutes and organizations to stay ahead of the curve in the electromechanical engineering field. Our facility's strategic partnerships with the University of Twente, the Fraunhofer Institute of Production Technology, and the AMC Advanced Manufacturing Center enable a dynamic exchange of knowledge and expertise. With a focus on manufacturing 4.0 and smart production, Benchmark Almelo embraces the concept of increased smart and automated production, allowing us to localize manufacturing while reducing logistical emissions and costs.

Benchmark Almelo recognizes the increasing demand for sensor and control systems across various sectors. Working collaboratively with many of our customers, we actively contribute to this transition toward higher energy efficiency and the digitalization of society. We are honored to support integrating electronic devices in various sectors, including healthcare, avionics, complex industrials, and semiconductor capital equipment. By keeping in stride with these developments and megatrends, we help significantly impact the evolving industrial landscape.

Works Cited

¹ [“The MEGA-TRENDS.” ESPAS – Global Trends to 2030](#)
| ESPAS

² [“Frost & Sullivan Analyzes the Mega Trends Transforming the United States through 2030.”](#) Frost & Sullivan, 20 May 2021 | Frost & Sullivan

³ [The Economic Potential of Generative AI](#) | McKinsey & Company

⁴ Agriculture Robotic and Autonomous Car Working in Smart Farm, Future 5G Technology with Smart Agriculture Farm Concept | Shutterstock

⁵ Futuristic Technology Concept: Team of Engineers and Professional[s] Workers in Heavy Industry Manufacturing Factory that is Visualized with Graphics into Digital Twin of Industry 4.0 High Tech | Shutterstock

⁶ Concept for Future Business Growth and Environmental Sustainability and [Reduce] Pollution for Future Business and Environmental Growth | Shutterstock

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