HSBI

Hochschule Bielefeld

University of Applied Sciences and Arts



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Future trends in technology and society and how to evaluate sources

FTS-05 · Future Technologies and Sustainability

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GUIDING QUESTIONS

- Which future trends are changing the work of mechatronics engineers and industrial engineers?
- How do you evaluate a source?
- How do you take steps 1 to 4 for your trend in phase 2?



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INTENDED LEARNING OUTCOMES

- You name current technological and social trends and classify their effects on the job profile of engineers.
- You distinguish types of sources, classify publications funded by industry with their interests and ask what a study has examined and how.
- You put the same question to an artificial intelligence (AI) service twice and compare the two answers.
- You sign up for a trend and formulate your own answer to its question.



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AGENDA

1. What lies ahead? Future trends at a glance
2. Who says so? Evaluating sources
3. Your trend, your question – phase 2 step by step
4. Which trend will be yours? The 20 trends one by one
5. What have you learnt today?



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REVIEW OF FTS-04

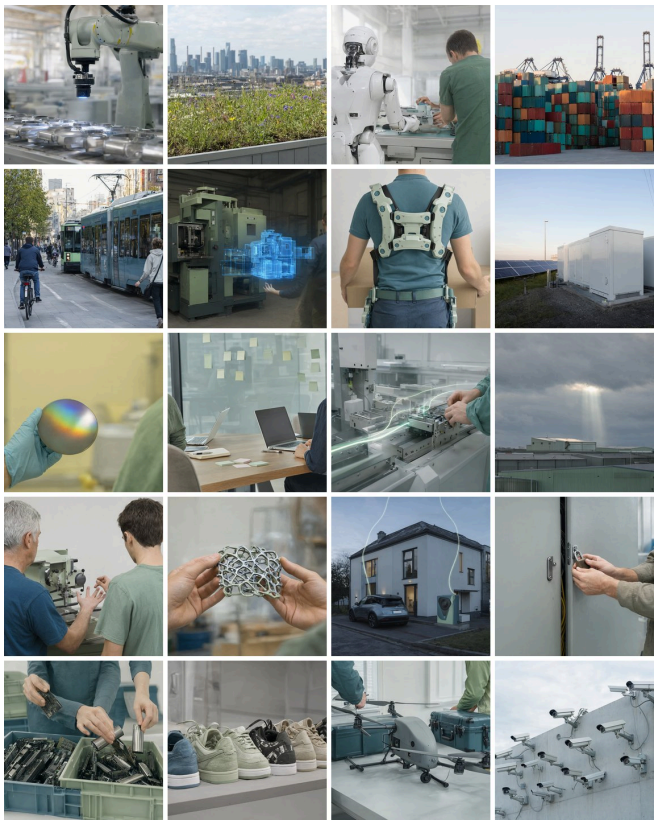
- Elevator talk: comprehensibility in focus – everybody in the room should understand your question and your balanced, reflective answer
- Phase 1: all five steps of the didactic concept once
- Questions for reflection: what you have learnt and what you will do differently
- Phase 2 follows the same pattern, with a new topic and with sources in focus
- Today: phase 2 begins – the future trends and how to evaluate a source

1 What lies ahead?

- What is a future trend?
- Nine technological trends
- Eleven social trends
- What the trends mean for your job profile

WHAT IS A FUTURE TREND?

- 20 future trends: developments that can be observed today and are changing the work of mechatronics engineers and industrial engineers
- Nine technological and eleven social
- Compiled from reports by consultancies, a trade association, a trade magazine, a futures institute and the World Economic Forum
- Megatrends act globally and over the long term (European Commission 2020, p. 1)
- A trend tells you that something is under way, not how it will end



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NINE TECHNOLOGICAL TRENDS

- Artificial intelligence
- Digital twins
- Robotics and autonomous systems
- Additive manufacturing and smart materials
- Energy systems and electrification
- Connected and software-defined production
- Cybersecurity of operational technology
- Microelectronics and power semiconductors
- Circular economy and digital product passport

- Mechatronics engineers: mainly implementing a technology
- Industrial engineers: scaling it economically, optimizing it, deciding on its strategy
- Example, digital twins: commissioning a machine virtually – or simulating a factory and planning scenarios
- The same trend, but a different desk; the assignment is mine and names examples, not limits

ELEVEN SOCIAL TRENDS

- Demographic change and shortage of skilled workers
- Geoeconomic fragmentation and resilience
- Security and defence
- Mobility and urbanization
- Health and care
- Individualization
- Neo-ecology and climate change
- Economic uncertainty
- Connectivity
- Ethics of digitalization and disinformation
- New work and lifelong learning

- Developments in society, the economy and politics, including sustainability and ethical aspects of digitalization (HSBI 2026, p. 41)
- They, too, reach the desks of engineers; the assignment is mine
- Trends do not stand alone: individualization, for example, is linked to additive manufacturing

WHAT THE TRENDS MEAN FOR YOUR JOB PROFILE

- The job profile changes in what engineers work on and in what they need to be able to do
- One attempt to describe this: the Future of Jobs Report of the World Economic Forum (WEF), a survey of over 1 000 employers (WEF 2025)
- What you will work on: employers expect AI and information processing (86 %), robotics and automation (58 %) and the generation, storage and distribution of energy (41 %) to transform their business by 2030 (ibid.)
- What you will need: analytical thinking above all, then resilience, flexibility and agility, then leadership and social influence (ibid.)
- But: expectations of employers, not measurements – and the report wants something (ibid.)
- The same applies to my list of 20 trends. Can you rely on them?

2 Who says so?

- One question, four publications
- Tool 1: Types of sources
- Tool 2: Publications funded by industry and their interests
- Tool 3: What a study has examined and how
- Tool 4: The same question twice

ONE QUESTION, FOUR PUBLICATIONS

- ‘Does hydrogen make steel production climate-neutral?’ We go on looking and find, among others:

Publication	What it is	What it says
SSAB (2021, pp. 1–2)	Press release of a steel company	SSAB says it has made ‘the first fossil-free steel in the world’ and handed it over to a customer, in a trial delivery. The release names neither an amount nor an emissions figure for this steel.
EUROFER (2019, p. 2)	Roadmap of the European Steel Association (EUROFER)	The European steel industry could cut its carbon emissions by 80–95 % by 2050, ‘under the right conditions’.
Pei et al. (2020, section 3)	Article in the journal *Metals* by employees of the steel company SSAB, the mining company Luossavaara-Kiirunavaara Aktiebolag (LKAB), the energy company Vattenfall and their joint venture	In an example from northern Sweden, fossil carbon dioxide (CO_2) falls from 1 600 kg to 25 kg per tonne of crude steel.
Vogl et al. (2018, pp. 740–741)	Article in the *Journal of Cleaner Production* by researchers at Lund University	Carbon, lime and graphite electrodes cause 53 kg of CO_2 per tonne of steel; the blast furnace route emits 1 870 kg.

- Steel from the Hydrogen Breakthrough Ironmaking Technology (HYBRIT) project was delivered in 2021 – by SSAB, as a trial delivery; so far, the company itself is our only witness (SSAB 2021, p. 1)
- All four sound serious, yet three name different figures and one names none for its steel. Whom do you believe? Four tools: types of sources, interests, what was examined, the same question twice

TOOL 1: TYPES OF SOURCES

- Evaluating sources starts with the type of source: What kind of publication is it, and who checked it?
- Grey literature: no commercial publisher controls it – place it by the expertise of the producer and by outlet control (Garousi et al. 2019, pp. 3–4)

Type of source	Examples (ibid., p. 4)	In our case
Scientific literature ('white' literature in the model)	Published journal papers, conference proceedings, books	Vogl et al. (2018), Pei et al. (2020)
Grey literature, first tier: high outlet control, high credibility	Books, magazines, government reports, white papers	EUROFER (2019)
Grey literature, second tier: moderate outlet control, moderate credibility	Annual reports, news articles, presentations, videos, question-and-answer sites, wiki articles	SSAB (2021)
Grey literature, third tier: low outlet control, low credibility	Blogs, emails, tweets	–

- A lower tier does not make a publication useless, and the type alone is not enough
- The AI answer is never a source and never evidence

TOOL 2: PUBLICATIONS FUNDED BY INDUSTRY

- Who wrote it, who paid for it, who benefits? Look at affiliations, funding and conflict of interest
- **SSAB:** its own success, in a press release
- **EUROFER:** steel companies and national steel federations as members (EUROFER 2019, p. 18), demands at the end of its roadmap (ibid., pp. 16–17)
- **Pei et al.:** employees of the companies whose project they describe; ‘The authors declare no conflict of interest.’ (Pei et al. 2020)
- **Vogl et al.:** Lund University, no competing financial interests, but funding within the project HYBRIT-RP1 (Vogl et al. 2018, p. 744)
- An interest does not make a statement wrong; ask further: Do the data back up the conclusions? (Garousi et al. 2019, p. 19)
- Drugs and medical devices: studies sponsored by the manufacturer report favourable results more often (Lundh et al. 2017)
- ExxonMobil: 83 % of the peer-reviewed papers acknowledged that climate change is happening and that humans cause it; 12 % of the paid advertisements (Supran and Oreskes 2017, p. 1)
- Objectivity: all relevant points of view (Jungmann 2025, p. 14), and say who is speaking: ‘According to the steel association EUROFER …’ is different from ‘Studies show …’

TOOL 3: WHAT A STUDY HAS EXAMINED AND HOW

- Validity: a method captures what it claims to capture (Jungmann 2025, p. 18) – these figures measure different things

Publication	Figure	Compared with	What it covers, under which conditions
Vogl et al. (2018, pp. 740–741)	53 kg of CO_2 per tonne of steel	1 870 kg, blast furnace route	One tonne of steel by hydrogen direct reduction, with carbon, lime and graphite electrodes counted; assumes electricity free of emissions
Pei et al. (2020, section 3)	25 kg of fossil CO_2 per tonne of crude steel	1 600 kg, blast furnace route of SSAB	An example in northern Sweden with renewable electricity and biomass; counts fossil CO_2 only
EUROFER (2019, pp. 2, 4, 6)	Cuts of 80–95 %	1990 levels	The whole European steel industry by 2050, with several technologies; only given CO_2-free electricity and hydrogen

- The conditions decide: with a grid above 532 kg of CO_2 per megawatt-hour and without scrap, hydrogen direct reduction emits more than the blast furnace route (Vogl et al. 2018, p. 740)
- Ask: What exactly was measured? Compared with what? For which region and which period? Under which assumptions? What was left out?

TOOL 4: THE SAME QUESTION TWICE

- Reliability: repeated under the same conditions, a study leads to comparable results (Jungmann 2025, p. 19) – and an AI service?
- Language models are not deterministic: for 48 to 76 % of the tasks, depending on the data set, there was no test in which the code from all five requests to ChatGPT gave the same output (Ouyang et al. 2025, pp. 1, 8) – for code, not for questions like yours
- Phase 2: your question twice – word for word, same service, same model and mode, new chat, without memory where possible; compare the answer, the figures and the sources
- Reliability is not truth: two answers that agree can both be wrong, so you still check them against the sources
- **Your turn:** apply the tools to short cases, here in the session

Our example question, twice

‘Commonly cited reductions are in the range of 80 to over 90 % compared with the blast furnace route, depending on assumptions.’ (Claude, Claude app for macOS, Claude Opus 5.5 with effort xhigh, queried 2026-10-16) – *AI output, quoted as an example – not evidence.*

‘With renewable power, hydrogen-based steel can get close to zero, with reductions often estimated at 90% or more compared with the blast furnace route.’ (Claude, Claude app for macOS, Claude Opus 5.5 with effort xhigh, queried 2026-11-02) – *AI output, quoted as an example – not evidence.*

Checked: 90 % or more is confirmed in part – with emission-free electricity, carbon, lime and graphite electrodes still cause 53 kg of CO_2, which is 2.8 % of the blast furnace route (Vogl et al. 2018, p. 741), but CO_2 is also embedded in the extraction of iron ore and limestone (ibid., p. 740)

3 Your trend, your question

- Your trend, your pair and your question
- Your AI service and your source package
- Steps 1 to 4 again – what is new
- From today to your elevator talk

YOUR TREND, YOUR PAIR AND YOUR QUESTION

- Today: sign up for one of the 20 future trends in ILIAS – four places per trend
- Choose by interest: you work with it until the elevator talk, and in phase 3, you can link your term paper to it
- The four of you form a trend group and divide yourselves into two pairs; each pair shares a source package
- Only two or three of you: each of the two source packages is taken by at least one of you
- Alone in your trend at the end of the exercise time: join a trend group that still has free places
- Each trend has exactly one question – all four of you work on it
- Your own answer: written in the session today, before you consult the AI service or your source package



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YOUR AI SERVICE AND YOUR SOURCE PACKAGE

- Step 3: one AI service per trend; both pairs of a trend use the same service

AI service	Access	Trends
ChatGPT	https://chatgpt.com	Artificial intelligence; Cybersecurity of operational technology; Mobility and urbanization; Ethics of digitalization and disinformation
Perplexity	https://www.perplexity.ai	Digital twins; Microelectronics and power semiconductors; Health and care; New work and lifelong learning
Claude	https://claude.ai	Robotics and autonomous systems; Circular economy and digital product passport; Individualization
Gemini	https://gemini.google.com	Additive manufacturing and smart materials; Demographic change and shortage of skilled workers; Neo-ecology and climate change
Vibe by Mistral AI	https://chat.mistral.ai	Energy systems and electrification; Geoeconomic fragmentation and resilience; Economic uncertainty
Grok	https://grok.com	Connected and software-defined production; Security and defence; Connectivity

- Registration an obstacle? Use the chat service with artificial intelligence of HSBI (HSBIKI) instead
- Step 4: ask to join the Zotero group FTS-resources-2; use the source package of your pair

STEPS 1 TO 4 AGAIN – WHAT IS NEW

- The five steps stay the same; in steps 1 to 4, three things are new:
- **Step 1:** You do not choose – adopt the question of your trend word for word
- **Step 3:** Your question to your AI service twice; save both answers, check the sources they name, compare the two answers
- **Step 4:** Read your source package with the tools of this lesson; note the answers together with the statements you want to use
- Step 5 follows in FTS-06, after an exchange in your trend group

For your next poster

- One file in the Portable Document Format (PDF) with one page
- Your question word for word, your trend below it, your name in the strip
- The AI answer as a quotation with its long reference and the note – and your check of the sources it names
- Author, year and page at every statement from a source; your bibliography lists exactly the sources you cite
- Your balanced, reflective answer compares the AI answer with the scientific answer

FROM TODAY TO YOUR ELEVATOR TALK

- Today, FTS-05: sign up for your trend, form your pair, adopt your question and write down your own answer
- Until FTS-06 on 13 November: steps 3 and 4 on your own
  - Step 3: Putting your question to the AI service twice, checking its sources and comparing the two answers
  - Step 4: Reading the texts of your source package and noting where each statement comes from
- FTS-06 on 13 November: exchange in your trend group, weighing up (step 5) and completing your poster
- Poster upload in ILIAS: Wednesday 18 November 2026 at 23:55
- FTS-07 on 20 November: elevator talks
  - In 60 to 90 seconds, briefly and concisely: your question, your own answer, what the scientific sources say, how the AI answer fits in, and the insight you take away from the exercise

4 Which trend will be yours?

- Each trend: what it is about, where it stands, where its limits lie, what you can do with it and your question in phase 2
- Sources of very different kinds: use the tools from chapter 2 on them
- The tasks for the two degree programmes are my own assignment

ARTIFICIAL INTELLIGENCE

Industrial AI, AI agents and the regulation of AI



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- Where it stands: 19.95 % of enterprises in the European Union (EU) with at least ten employees used AI in 2025; large enterprises 55.03 % (Eurostat 2025a, p. 1)
- Limits: enterprises that considered AI without using it name lack of expertise and unclear legal consequences (ibid., p. 9); data centres, with AI as one use, consumed around 1.5 % of global electricity in 2024 (IEA 2025b, p. 14)
- Mechatronics engineers: AI on the controller, image processing for quality control, proof of safe and robust functions
- Industrial engineers: predictive maintenance, return on investment, risk classes of the AI Act, where humans keep control
- **Your question:** ‘Do AI assistants make engineers more productive?’

DIGITAL TWINS

A virtual representation of a system, kept up to date with data from its real counterpart (National Academies 2024, p. 1)

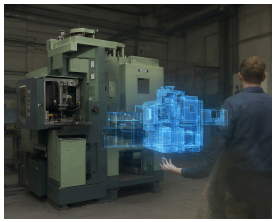


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- Where it stands: in Germany, 45 % of industrial companies with at least 100 employees used them in production in 2026, in a telephone survey by the digital association Bitkom (Bitkom 2026, slides 7, 17)
- Limits: no agreed definition (Voas et al. 2025, p. 2); methods and standards for continuous verification and validation still lacking (National Academies 2024, pp. 7–8)
- Mechatronics engineers: virtual commissioning, control code validated before the hardware is built
- Industrial engineers: simulation of processes and supply chains, factory layout, costs analysed in real time
- **Your question:** ‘Do digital twins reduce the time and cost of commissioning machines?’

ROBOTICS AND AUTONOMOUS SYSTEMS

Human-robot collaboration, physical AI and humanoid robots



Image by Qwen-Image 2.1

- Where it stands: 542 076 industrial robots installed worldwide in 2024; 67 819 in the EU, 8 % fewer than the year before – figures from an association (Müller 2025, pp. 13–14)
- Limits: tools for assessing the risks of advanced robots are still rare; standards pay too little attention to real use, say the experts interviewed (Rosen et al. 2022, p. 33)
- Mechatronics engineers: flexible end effectors, sensors, functional safety, training in simulation
- Industrial engineers: ergonomics and occupational safety, managing change, deployment in logistics and assembly
- **Your question:** ‘Do collaborative robots pay off compared with conventional industrial robots?’

ADDITIVE MANUFACTURING AND SMART MATERIALS

Parts built from 3D model data, usually in layers (EPO 2023, p. 7); among smart materials, shape memory alloys

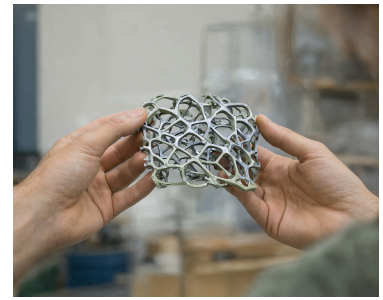


Image by Qwen-Image 2.1

- Where it stands: revenue of 24.2 billion US dollars (USD) worldwide in 2025, according to a trade magazine (Davies 2026); more than 8 090 international patent families in 2020 (EPO 2023, p. 9)
- Limits: qualification and certification count among the obstacles to wider use (ibid., p. 23)
- Mechatronics engineers: parts with integrated functions, lightweight structures, shape memory alloys
- Industrial engineers: production on demand, decentralized production, unit costs for small batches
- **Your question:** ‘Is additive manufacturing more sustainable than conventional manufacturing?’

ENERGY SYSTEMS AND ELECTRIFICATION

End uses run on electricity instead of other fuels (IEA 2025a, p. 336); renewable energy, hydrogen, battery storage, grids



Image by Qwen-Image 2.1

- Where it stands: electricity covered 21 % of total final energy consumption worldwide in 2024 (ibid., pp. 19, 196); more than 680 gigawatts (GW) of renewable capacity added in 2024 (ibid., p. 40)
- Limits: solar and wind projects with some 2 800 GW waiting to be connected (ibid., p. 147); a single country is the leading refiner of 19 out of 20 strategic minerals for energy (ibid., p. 18)
- Mechatronics engineers: fuel cells and electrolysis, power electronics, battery and thermal management, electrified drives
- Industrial engineers: carbon footprint, energy audits, life cycle costs, critical raw materials, recycling of batteries
- **Your question:** ‘Are battery-electric or hydrogen trucks the better choice for long-haul freight?’

CONNECTED AND SOFTWARE-DEFINED PRODUCTION

Industrial Internet of Things (IIoT), edge computing and control software separate from the hardware

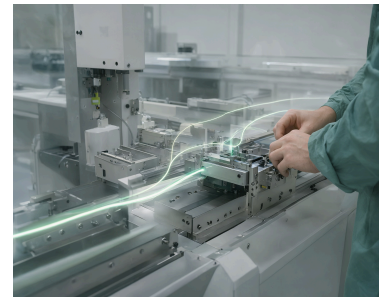


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- Where it stands: 689 private networks of the fifth generation of mobile communications (5G) in the EU by the end of 2025, part of the data estimated (IDATE and Schuman Associates 2026, pp. 10, 69, 74, 104)
- Limits: member states regulate access to frequencies differently (ibid., p. 69); IEC 61499 is still not widely used, because IEC 61131-3 has a head start (Ashiwal et al. 2025, pp. 575–576)
- Mechatronics engineers: fieldbus or 5G campus networks, edge devices, control logic as software on standard hardware
- Industrial engineers: platform architectures, pay-per-use models, less dependence on individual vendors of controllers
- **Your question:** ‘Does 5G in factories offer benefits that Wi-Fi cannot?’

CYBERSECURITY OF OPERATIONAL TECHNOLOGY

Programmable equipment that senses or changes the physical world, such as industrial control systems (Stouffer et al. 2023, p. 8)



Image by Qwen-Image 2.1

- Where it stands: in 2025, manufacturing had the highest share, 25.2 %, of the ransomware attacks claimed by the attackers (ENISA 2026, p. 49); the Cyber Resilience Act applies in general from 11 December 2027, its reporting obligations since 11 September 2026 (European Union 2024b, pp. 38, 67)
- Limits: updates have to be tested thoroughly and outages planned in advance (Stouffer et al. 2023, pp. 29–30); systems often remain in use for 10 to 15 years or longer (ibid., p. 30)
- Mechatronics engineers: security by design, network segmentation, secure updates, guided by IEC 62443
- Industrial engineers: risk and emergency planning, Cyber Resilience Act, Network and Information Security Directive (NIS2), attacks via suppliers
- **Your question:** ‘Should a company hit by ransomware pay the ransom?’

MICROELECTRONICS AND POWER SEMICONDUCTORS

Microchips, embedded systems and power semiconductors, the core of power electronic systems (US DOE 2022, p. vii)

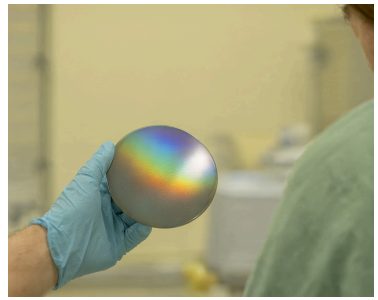


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- Where it stands: worldwide sales of USD 795.6 billion in 2025, a figure from an organization of the manufacturers themselves (WSTS 2026, pp. 1–2); EU target of a 20 % share, 11.7 % forecast for 2030 (ECA 2025, p. 7)
- Limits: supply chain very exposed to geopolitical tension (ibid., p. 44), manufacturing concentrated in East Asia (ibid., p. 48)
- Mechatronics engineers: silicon carbide (SiC) and gallium nitride (GaN) in inverters and drives, microcontrollers in embedded systems
- Industrial engineers: strategies against shortages, such as second sources and stockpiling; dependence on individual countries
- **Your question:** ‘Is silicon carbide worth its higher price in electric drives?’

CIRCULAR ECONOMY AND DIGITAL PRODUCT PASSPORT

Keeping products, materials and resources valuable for as long as possible (Eurostat 2025b, p. 2)



Image by Qwen-Image 2.1

- Where it stands: recycled waste supplied 12.2 % of the materials used in the EU in 2024 (ibid., p. 7); certain batteries will need a passport from 18 February 2027, according to the regulation as adopted in 2023 (European Union 2023a, p. L 191/72)
- Limits: some materials cannot be recycled at all (Eurostat 2025b, p. 8); while buildings and infrastructure need more material than recycling can supply, primary extraction remains necessary (ibid., p. 5)
- Mechatronics engineers: design for repair, disassembly and recycling, remanufacturing
- Industrial engineers: EU Ecodesign Regulation, digital product passport, traceability, take-back and product as a service
- **Your question:** ‘Will the digital product passport make products more circular?’

DEMOGRAPHIC CHANGE AND SHORTAGE OF SKILLED WORKERS

An ageing population (ELA 2025, p. 7); a skills shortage: demand for a skill exceeds its supply at the market wage (ibid., p. 8)



Image by Qwen-Image 2.1

- Where it stands: 22.0 % of the people in the EU were 65 or older on 1 January 2025 (Eurostat 2026a, p. 1); 429 of 436 occupations with labour or skills shortages in at least one reporting country in 2024 (ELA 2025, pp. 9, 16)
- Limits: each country sets its own threshold (ibid., p. 17), and the shortage cannot be attributed to demography alone (ibid., p. 9)
- Mechatronics engineers: automation of tasks for which workers are missing, assistance systems, ergonomic workplaces
- Industrial engineers: succession planning, securing knowledge when people retire, international skilled workers
- **Your question:** ‘Do ageing workforces reduce the productivity of factories?’

GEOECONOMIC FRAGMENTATION AND RESILIENCE

A reversal of global economic integration brought about by policy (Attinasi et al. 2024, p. 10)



Image by Qwen-Image 2.1

- Where it stands: world trade on most-favoured-nation terms: roughly 80 % in 2022; about 72 % in early 2026 (WTO 2026, p. 35)
- Limits: trade integration has so far held up, and the decoupling shows up in a few trade relations (Attinasi et al. 2024, p. 5); goods can reach their destination by way of neutral countries (ibid., p. 6)
- Mechatronics engineers: interchangeable components and second sources, regional standards, export regulations
- Industrial engineers: diversified supply chains, reshoring and friendshoring, tariffs and export controls
- **Your question:** ‘Should companies switch from just-in-time to just-in-case?’

SECURITY AND DEFENCE

Dual use: goods, software and technology that can serve civil and military purposes (European Union 2021, p. L 206/6)



Image by Qwen-Image 2.1

- Where it stands: world military expenditure of USD 2 887 billion in 2025 – 2.9 % more in real terms; Europe USD 864 billion, 14 % more (Liang et al. 2026, p. 1)
- Limits: European defence industry too slow and too fragmented, says a political paper (European Commission and High Representative 2025, pp. 6, 12–13); the figures may become less clear (Liang et al. 2026, p. 8)
- Mechatronics engineers: robust systems, technologies with civil and military uses, such as drones, sensors and drives
- Industrial engineers: market and employer, export control of dual-use goods, security clearances, critical infrastructure
- **Your question:** ‘Does military research and development boost civilian innovation?’

MOBILITY AND URBANIZATION

Urbanization changes how and where people live and work (UN DESA 2025, p. IX)



Image by Qwen-Image 2.1

- Where it stands: 45 % of the world's population lived in cities in 2025 (ibid., p. IX); more than 20 million electric cars sold in 2025, a quarter of all new cars (IEA 2026, p. 10)
- Limits: in 350 cities, convenient access to public transport rose to 60.4 % by 2025, not enough given how fast cities are growing (UN Statistics Division 2026, p. 3); fully autonomous cars (level 5) are not currently in sight, although driverless taxis (level 4) already run commercially in more than 20 cities (IEA 2026, p. 163)
- Mechatronics engineers: electric drives, sensors and control for autonomous driving, charging infrastructure
- Industrial engineers: last mile, sharing and mobility as a service, connected transport infrastructure
- **Your question:** ‘Do cargo bikes make urban deliveries more efficient?’

HEALTH AND CARE

More demand for care, fewer people of working age to finance and provide it (OECD and European Commission 2024, p. 3)



Image by Qwen-Image 2.1

- Where it stands: estimated shortage of about 1.2 million doctors, nurses and midwives in the EU in 2022, measured against minimum staffing thresholds (ibid., p. 13)
- Limits: young people's interest in nursing declined in more than half of the EU countries (ibid., p. 13); capacity for assessing the conformity of medical devices still not sufficient in 2023 (European Union 2023c, p. L 80/25)
- Mechatronics engineers: medical technology, care and rehabilitation robotics, exoskeletons for physical work
- Industrial engineers: health protection at work, approval of medical devices, markets of the health economy
- **Your question:** ‘Can robots relieve the staff in elderly care?’

INDIVIDUALIZATION

Mass customization: so many variants that nearly everybody finds what they want (Mourtzis 2016, pp. 3–4)



Image by Qwen-Image 2.1

- Where it stands: no statistics found for the EU or the world; a survey from 2023 covered 117 small and medium-sized enterprises in the Polish automotive industry: 55.56 % let customers take part in product design (Patalas-Maliszewska et al. 2025, pp. 22–23)
- Limits: implementation cannot yet be measured uniformly (ibid., p. 18); online configurators do not solve how the variants are to be assembled (Mourtzis 2016, p. 5)
- Mechatronics engineers: adaptable manufacturing for batch size 1, product configurators linked to manufacturing
- Industrial engineers: organizing mass customization, managing variants, calculating the costs of individual products
- **Your question:** ‘Does mass customization pay off for manufacturers?’

NEO-ECOLOGY AND CLIMATE CHANGE

Neo-ecology: a term from a futures institute (Zukunftsinstitut 2023); no peer-reviewed or official definition found



Image by Qwen-Image 2.1

- Where it stands: global temperature 1.43 ± 0.13 °C above the average of 1850 to 1900 in 2025 (WMO 2026, p. 1); 87 direct carbon pricing instruments covered 29 % of global greenhouse gas emissions on 1 April 2026 (World Bank 2026a, pp. 5, 13)
- Limits: most emissions have no direct carbon price, and prices differ widely (ibid., p. 22); the World Bank itself aims to support carbon pricing (ibid., p. 3)
- Mechatronics engineers: energy-efficient drives and plants, electrified processes, adaptation to heat and heavy rain
- Industrial engineers: carbon prices as a cost factor, sustainability reporting, what customers require
- **Your question:** ‘Are customers willing to pay more for climate-friendly products?’

ECONOMIC UNCERTAINTY

You cannot say how likely an event is; with risk, the probabilities are known (Bloom 2013, p. 3)



Image by Qwen-Image 2.1

- Where it stands: World Uncertainty Index at its highest value so far, 106 862, in the third quarter of 2025; 72 717 in the third quarter of 2026 (FRED 2026)
- Limits: no single measure captures uncertainty perfectly (Bloom 2013, p. 3); the index counts how often the word occurs in country reports (FRED 2026)
- Mechatronics engineers: modular and scalable products and plants, adaptable to fluctuating demand
- Industrial engineers: scenario planning, flexible cost structures, liquidity and risk management
- **Your question:** ‘Should companies cut investment in times of economic uncertainty?’

CONNECTIVITY

Products, machines and people linked by networks; connected products collect and pass on data (European Union 2023b, p. 34)



Image by Qwen-Image 2.1

- Where it stands: 74 % of the world's population online in 2025 (ITU 2025, p. 1); 5G networks reached 55 % (ibid., p. 9)
- Limits: low level of cybersecurity, inconsistent security updates (European Union 2024b, p. 1); 2.2 billion people offline (ITU 2025, p. ii); 5G covers 84 % of the population in high-income countries, 4 % in low-income countries (ibid., p. 9)
- Mechatronics engineers: remote maintenance, over-the-air updates, open interfaces and communication standards
- Industrial engineers: platform economy, data-based services, changing habits of customers
- **Your question:** ‘Does selling services instead of machines pay off for machine builders?’

ETHICS OF DIGITALIZATION AND DISINFORMATION

Protection from purely automated decisions in the EU (European Union 2016, p. L 119/46); disinformation has no clear definition (United Nations 2022, p. 2)



Image by Qwen-Image 2.1

- Where it stands: on average 62 % of respondents across 48 markets worried about whether what they see online is real in 2026 – an online survey (Egan et al. 2026); at least 83 states with new laws on ‘fake news’, disinformation and defamation by 2022 (United Nations 2022, p. 12)
- Limit: measures against disinformation can themselves infringe rights (ibid., p. 12)
- Mechatronics engineers: traceable, fair and safe automated decisions, privacy by design
- Industrial engineers: guidelines for data and AI, protection against disinformation, trust of customers and employees
- **Your question:** ‘Can watermarks reliably identify AI-generated content?’

NEW WORK AND LIFELONG LEARNING

Telework and hybrid work (WHO and ILO 2021, p. 1), agile development; lifelong learning, measured by adult participation (Eurostat 2026b, p. 1)



Image by Qwen-Image 2.1

- Where it stands: 46.6 % of adults aged 25 to 64 in the EU took part in education or training in the previous twelve months, survey of 2022; target for 2030: at least 60 % every year (ibid., p. 1)
- Limits: participation is uneven (ibid., p. 5); telework can put a strain on psychosocial well-being (WHO and ILO 2021, p. 7)
- Mechatronics engineers: further training throughout your working life, distributed international teams
- Industrial engineers: hybrid and flexible working models, reskilling and upskilling, new forms of leadership
- **Your question:** ‘Does agile development work as well for physical products as for software?’

5 What have you learnt today?

- The building blocks of knowledge
- Answers to the guiding questions

WHAT YOU HAVE LEARNT

- What a future trend is
- The trends and your job profile
- Types of sources
- Publications funded by industry and their interests
- What a study has examined and how
- The same question twice
- Phase 2 step by step
- The 20 trends one by one

ANSWERS TO THE GUIDING QUESTIONS

- Which trends? Nine technological and eleven social – the same trend has a different focus for each degree programme
- Evaluating a source? Type of source, interests, what was examined – and an AI answer is never a source: ask twice, compare, check against the sources
- Steps 1 to 4? Adopt your question, write down your own answer, ask your AI service twice and check its sources, read your source package with the tools of this lesson



Image by Qwen-Image 2.1

Your turn: sign up for your trend, form your pair, adopt your question and write down your own answer.

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