Main Technological Trends in Digitization and Industry 4.0 Affecting Work and Jobs

Bernd Dworschak

Fraunhofer Institute for Industrial Engineering IAO, Stuttgart

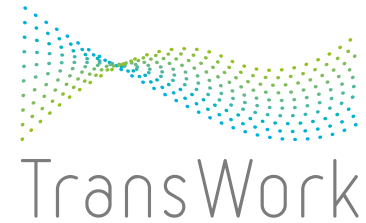**7th German-Brazilian Dialogue on Science, Research and Innovation
Working and learning in a digital world**

Sao Paulo, 31 October 2018

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Digitization
A preliminary working definition

- means the process of diffusion of information and commuication technologies (ICT) to all areas of life and work and the corresponding socio-economic change;

- means a qualitatively changed process of informatisation; that means generation, reproduction, development and processing of information and information systems;

- is characterised by digital networking of socio-technical application systems with (mobile) devices;

- means the application of working systems with increasing intelligent/self-learning technical systems parts, wherein distributed decisions on people and technology influence each other mutually.

The digital transformation of industry
Increasing automatisation by combination of classical technologies and artificial intellegence
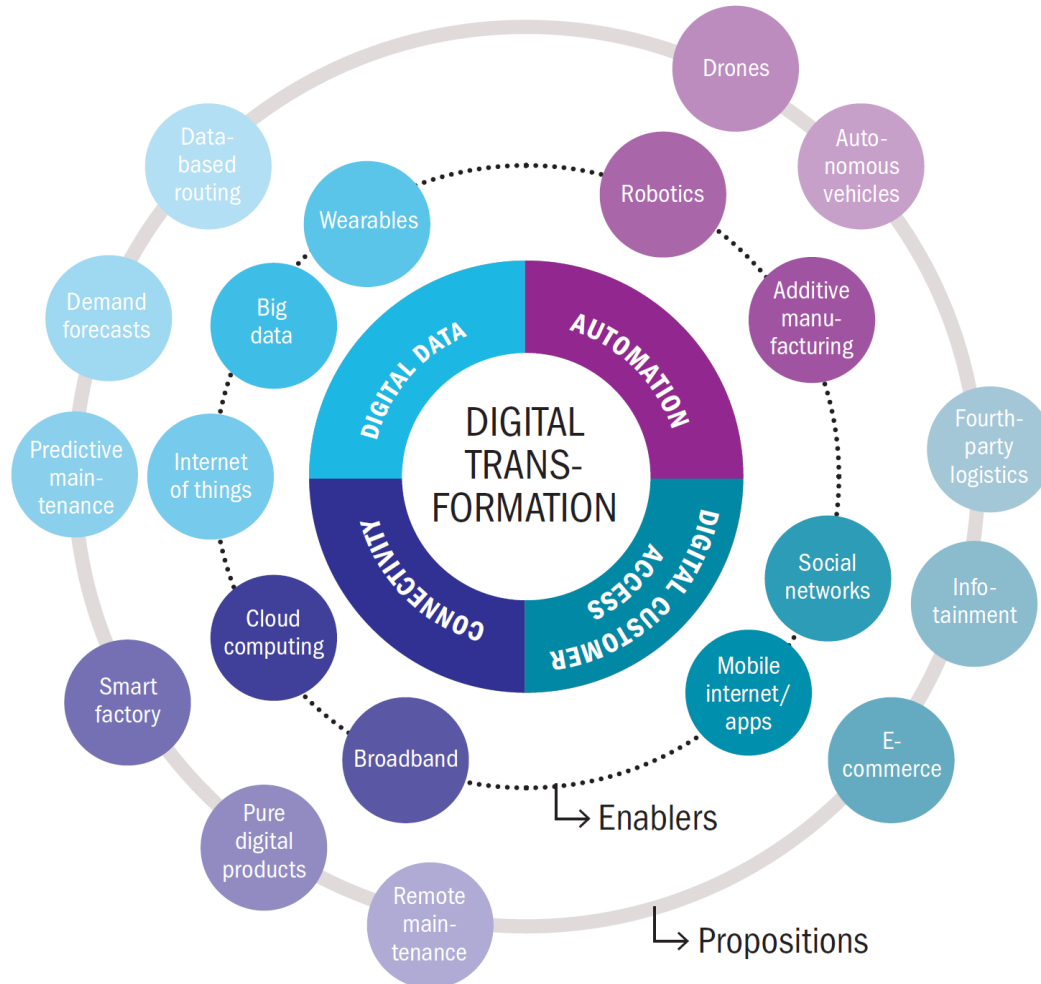
Source: http://www.rolandberger.de/media/pdf/Roland_Berger_The_digital_transformation_of_industry_20150315.pdf

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Industry 4.0
Technology framework

Intelligent Products

Sensors und Actuators

M2M / Social Machines

Plug & Produce

EMBEDDED SYSTEMS CPS

Data Protection

IT-SECURITY

SMART FACTORY

Low-Cost-Automation

Virtualization (VR/AR)

HMI

Information Security

CLOUD COMPUTING

ROBUST NETWORKS

Real Time Data

IPv6

Apps

Big Data

Broadband

Wireless

Mobile Devices
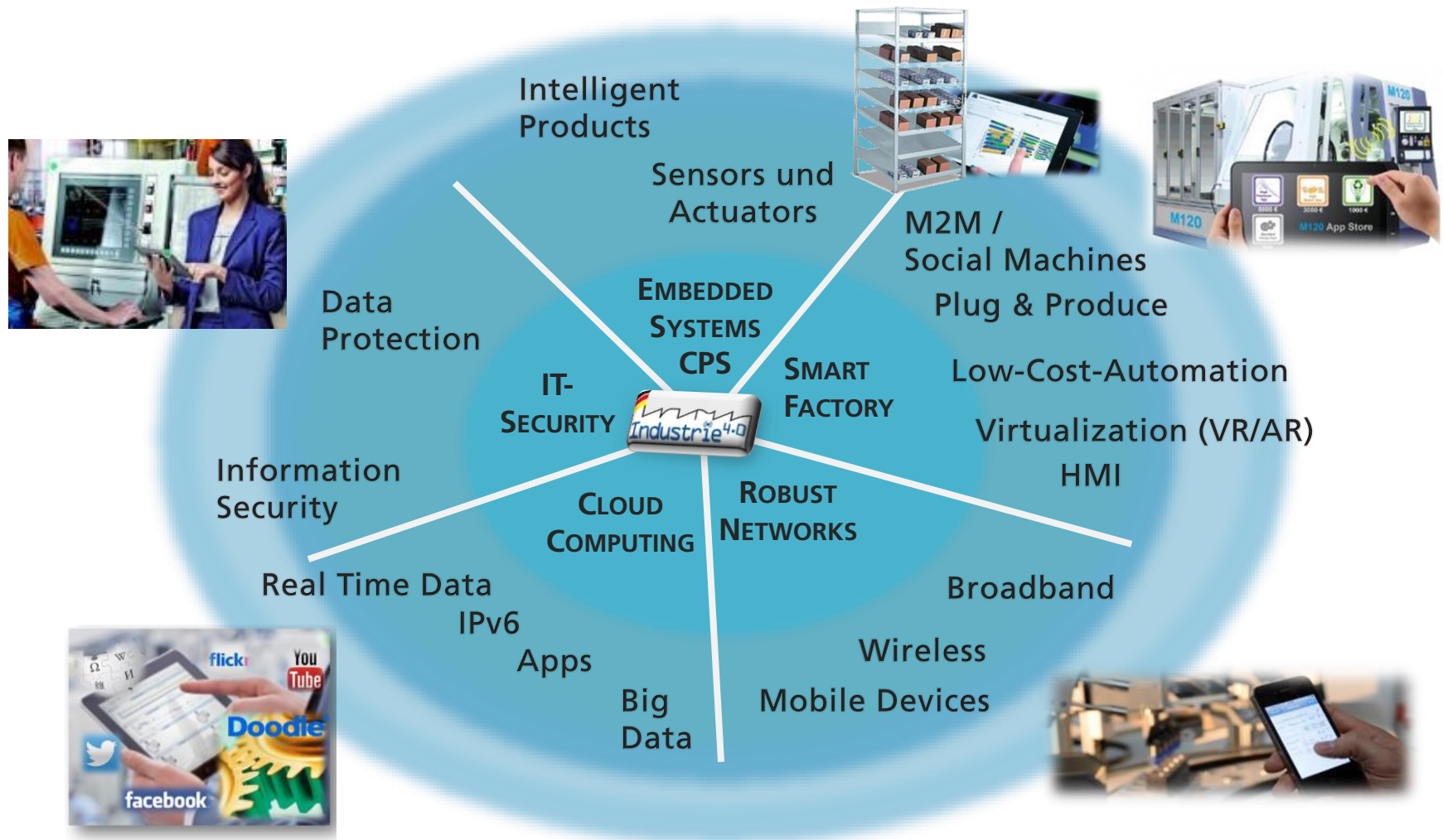
Sources: www.kuka.de; DFKI; McKinsey; Fraunhofer IAO

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World Economic Forum: The Future of Jobs Report 2018
Technologies by proportion of companies likely to adopt them by 2022 (projected)

Technology	%
User and entity big data analytics	85%
App- and web-enabled markets	75%
Internet of things	75%
Machine learning	73%
Cloud computing	72%
Digital trade	59%
Augmented and virtual reality	58%
Encryption	54%
New materials	52%
Wearable electronics	46%
Distributed ledger (blockchain)	45%
3D printing	41%
Autonomous transport	40%
Stationary robots	37%
Quantum computing	36%
Non-humanoid land robots	33%
Biotechnology	28%
Humanoid robots	23%
Aerial and underwater robots	19%

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Disruption map by industries
Digital transformation will change industries considerably

SHORT FUSE – BIG BANG

LONG FUSE – BIG BANG

Influence on the business model

IT&Media

Banks

Insurance

Retail

Education

Production

Health

Professional Services

Energy

Transport

Real estate

Agriculture

Government

Time (in years)

Travel

Catering

Construction

Mining, Oil, Chemistry

SHORT FUSE – SMALL BANG

LONG FUSE – SMALL BANG

0   1   2   3   4   5

0   5   10   15   20   25   30   35   40   45   50
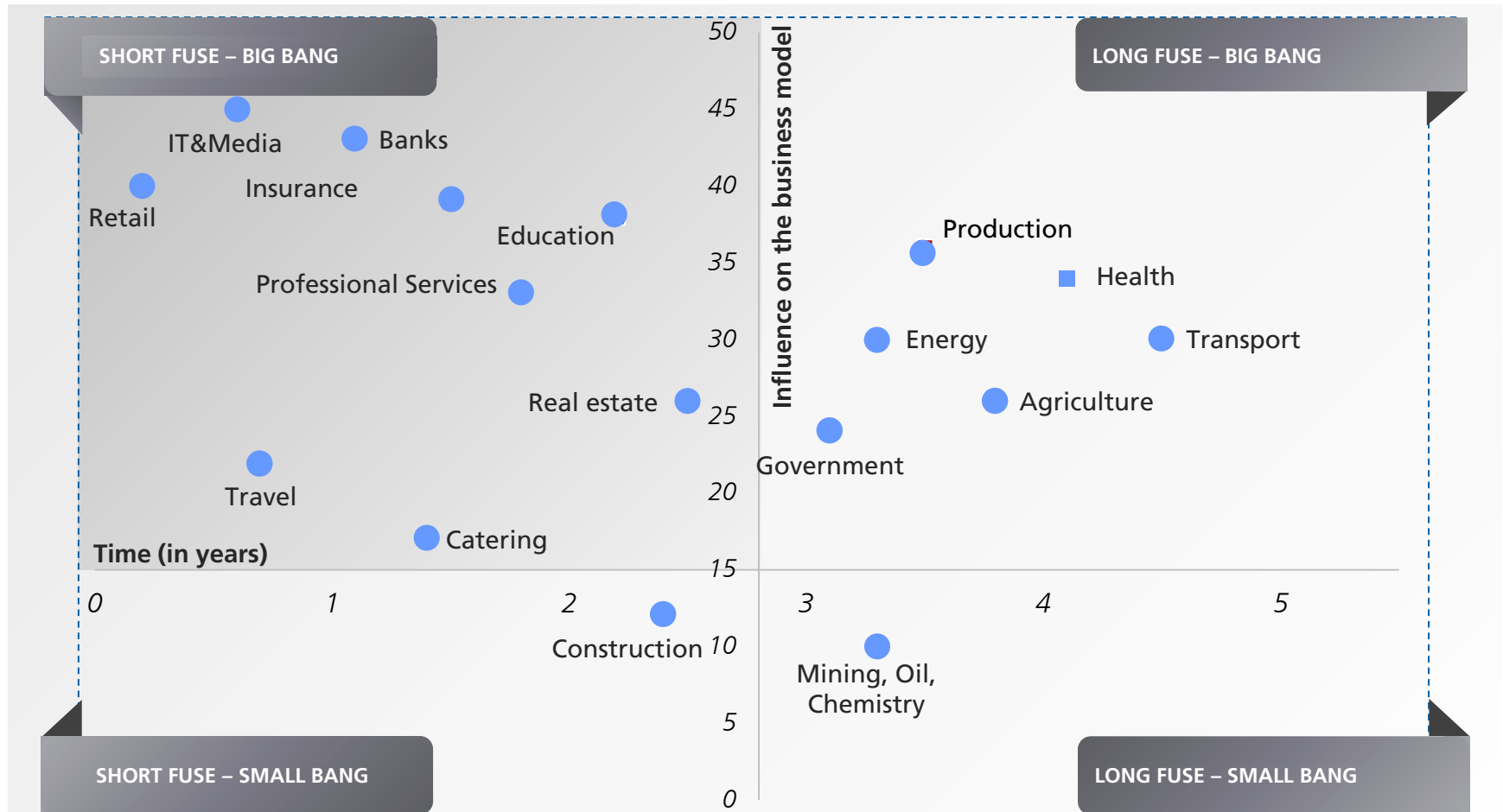
Quellen: Heads! und Deloitte Digital

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Future Work: Trends for designing Industry 4.0

Strongly increasing adaptability of working places with respect to context, people and tasks

Trends towards new forms of interaction at work

Context adaptive

Intuitive

Connected

Assisting

Increasing importance of real time displays of working processes and objects in a factory

Increasing importance of physical and digital assistant systems

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Future Work Trends: Connected working places
People, machines and systems exchange data in real time

Background

No IT systems without seamless connection of systems as well as process and product data

Opportunities

Connected objects & **real time usage** of relevant **production parameter** e.g. feedback of production events in the production control

Design

Production concepts 4.0 beyond Lean, **Acceptance of employees** if transparent, qualified for connected work and **interpretation of data**

Vernetzt

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Future Work Trends: Context sensitive working places
Working systems react on their environment in the future

Background

Differences of employees and processes as well as their demands not considered today

Opportunities

Usage of production context for personalisation of working area, e.g. adaption of working height, light situation and distribution of information for employees

Design

Establishing **rules** concerning the **usage of person-related data** and identification of potential rooms for individualisation

Kontextadaptiv

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Future Work Trends: Assisting working places
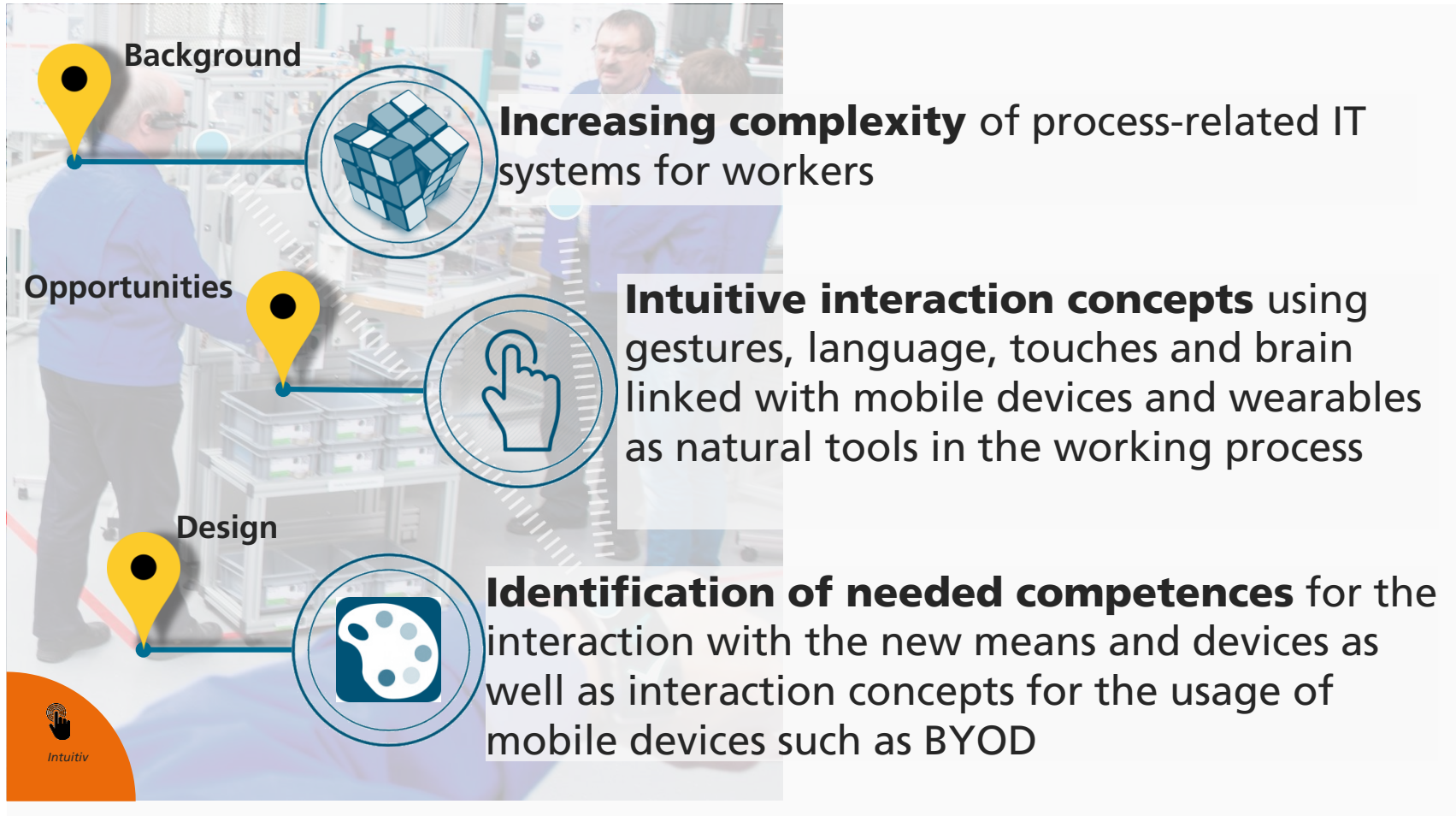## Working places support workers – also for further training

Background

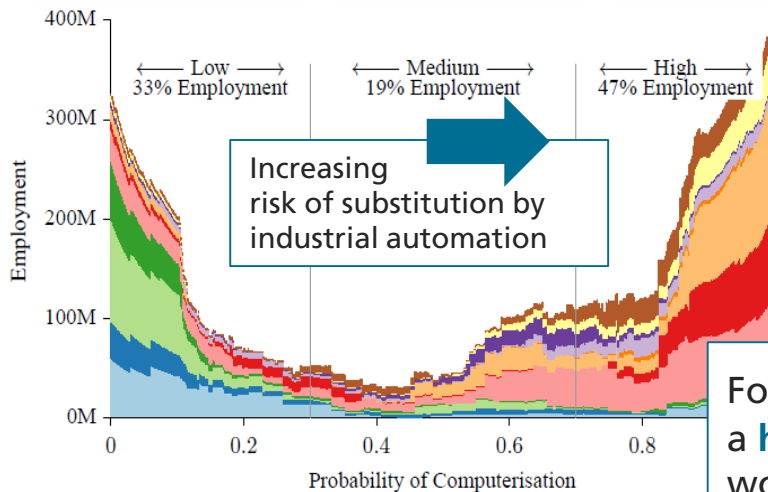**Richness of variants** by means of increasing individualisaton of products

Opportunities

Digital and physical assistance – Feedback-based, beneficial for learning, adaptive assistant systems supporting workers in the process (AR/VR, Exos)

Design

Distribution of control between people and technology, development of assisted working content vs. short intervals, development of **Learning scenarios in the working process/at work** by means of assisstant systems

Assistierend

Bildquelle: Porsche

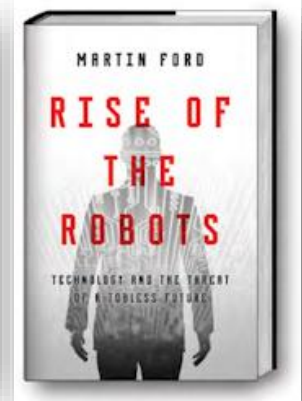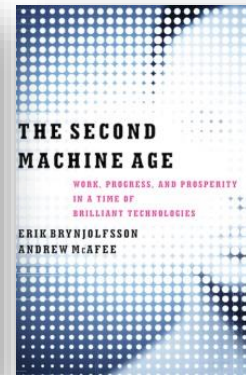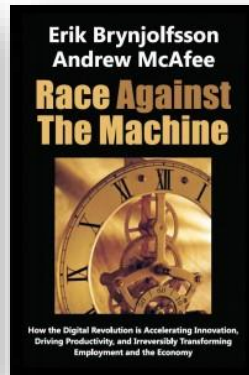Future Work Lab   Fraunhofer IAO

Future Work Trends: Intuitive working places
Working places tomorrow to be operated as easy like a smartphone

Background

Increasing complexity of process-related IT systems for workers

Opportunities

Intuitive interaction concepts using gestures, language, touches and brain linked with mobile devices and wearables as natural tools in the working process

Design

Identification of needed competences for the interaction with the new means and devices as well as interaction concepts for the usage of mobile devices such as BYOD

Intuitiv

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Work is changing
…consistently and once again.

Book covers: *Fabriken ohne Menschen*; *THE LIGHTS IN THE TUNNEL — AUTOMATION, ACCELERATING TECHNOLOGY AND THE ECONOMY OF THE FUTURE*, MARTIN FORD; *Erik Brynjolfsson, Andrew McAfee — Race Against The Machine — How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*; *ARBEITSFREI*; *THE SECOND MACHINE AGE — WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES — ERIK BRYNJOLFSSON ANDREW McAFEE*; *MARTIN FORD — RISE OF THE ROBOTS — TECHNOLOGY AND THE THREAT OF A JOBLESS FUTURE*

Chart axes: Employment (0M–400M) vs Probability of Computerisation (0–0.8). Low 33% Employment, Medium 19% Employment, High 47% Employment. Increasing risk of substitution by industrial automation.

Concept of technological unemployment
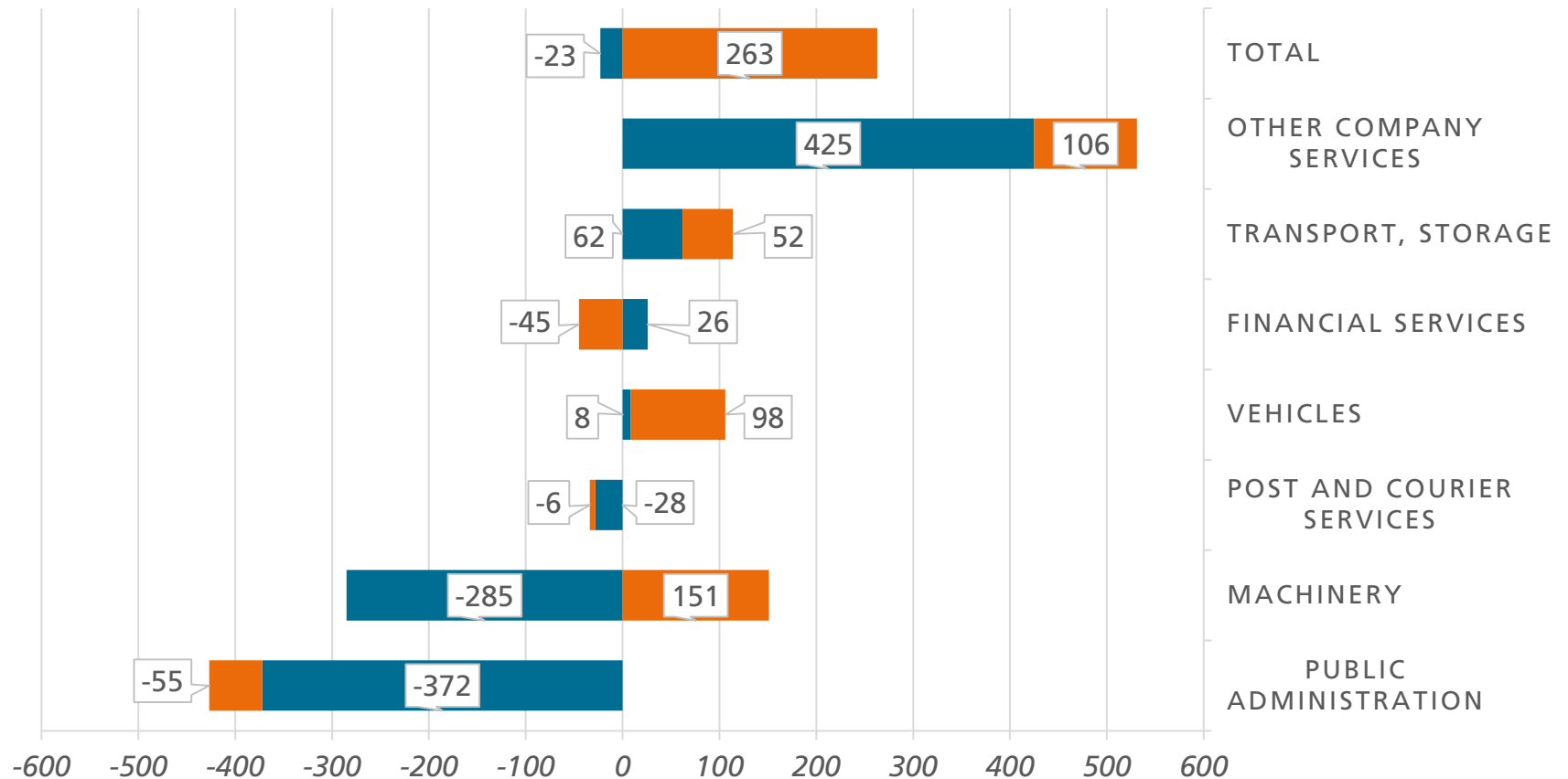Keynes (1933), Ricardo (1819)

»Technological progress is outperforming the creation of new working activities and places of employment.«

For **47 percent** of today´s US employees a **high risk** for digitisation/automation of their working activities exists.

Source: Frey, Osborne: The Future of Employment, 2013

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Forecast quantitative effects - BMAS 2030: Change workforce population 2014-2030 by industries (in 1.000) (selection)

■ *Basic scenario (migrants)*　　■ *Scenario Accelerated digitalisation*

Chart showing change in workforce population 2014-2030 by industries (in 1.000):

Industry	Basic scenario (migrants)	Scenario Accelerated digitalisation
TOTAL	-23	263
OTHER COMPANY SERVICES	425	106
TRANSPORT, STORAGE	62	52
FINANCIAL SERVICES	-45	26
VEHICLES	8	98
POST AND COURIER SERVICES	-6	-28
MACHINERY	-285	151
PUBLIC ADMINISTRATION	-372	-55

X-axis: -600, -500, -400, -300, -200, -100, 0, 100, 200, 300, 400, 500, 600

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Potential paths of development
The polarisation thesis

Automation scenario

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- Control and management tasks are taken over by digital technology.
- Workers are led by digital technology – **„directed work".**
- Digital **technology decides**, experience is not important.
- Comparatively simple »residual tasks« at middle-skilled level, dequalification

Specialisation scenario

- Digital technology **initiates and delivers i**nformation to **support decisions**.
- **Workers decide**, experience ist still important for decisions and problem solutions.
- Digital **technology** is **supporting decisions,** is used as tool, experience is basis for coordinated decisions,
- Potential for **job enrichment** and holistic work

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Fields of action of competence development

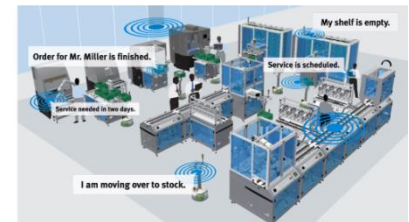## Work-integrated learning in the smart factory

- **System competence** by understanding connected, intelligent systems

- **Understanding processes** for physical and digital processes in cyber-physical systems (CPS)

- **Interdisciplinary/cross-functional working and learning**, in particular IT, electrical engineering and mechanics

- **Generic competences** for cooperation, communication and organisation in CPS

- **Strengthening decision-making** by autonomy versus intelligent systems

Challenge: Designing Industry 4.0 applications beneficial for learning and focussed on competence development!
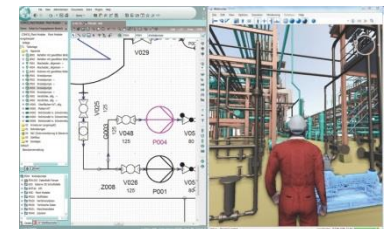
Simulations

Learning factories 4.0

Assistant systems

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»FUTURE WORK LAB«

Innovation Lab for Work , People and Technology at Fraunhofer Stuttgart

FUTURE WORK LAB«

Start-up funding:

Bundesministerium für Bildung und Forschung

Possible Value-Partner:

- Businesses as supplier and consumer
- Social partner
- Organizations
- Chambers

Demo World

Parcours 1 »Today+«

Parcours 2 »2025 Technology+«

Parcours 3 »2025 Human+«

Centre for competence development and counselling »Learning World«

| Module 1 | Module 2 | Module 3 | Module 4 | Module 5 | Module X |

Ideas world

Think Tank und shielded area for Research and Innovation focussing on Labour and Human-Technology-Interaction

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Learning World
Technologies and Topics

Assembly

Sensors

Engineering

Competence Development

Station 2: Assistierte Montage
- Personalisierter und mobiler Arbeitsplatz
- Qualifizierung mit Lernvideos
- Echtzeit-Datenvisualisierung

Station 6: Virtuelles Engineering
- Digital Industrial Engineering @ shopfloor level

Station 7: Qualifizierung 4.0
- Future Work-Lernwelt
- Seminare & Workshops

Station 3: Intelligente Sensorik
- Mobile Mehrmaschinenbedienung
- Retrofitting mit Sense & Act

Station 1: Mensch-Roboter-Interaktion
- Kollaboration mit dem Großroboter
- Einfache Roboterprogrammierung

Station 4: Sichere Produktionsarbeit
- Aktive Unfallprävention
- Szenenanalyse zur Unfallerkennung

Station 5: Optimierte Ergonomie
- Stuttgart Exo-Jacket
- Live-Visualisierung von Belastung
- Mobile Bewegungserfassung

Station 8: Digitalisierte Produktionsplanung
- KPI-Dashboard für Meister
- Schichtplanung per App
- Wirefree Arbeitsplätze
- Extended Workdesk

Human-Machine-Interaction

Safety

Ergonomics

Production Planning
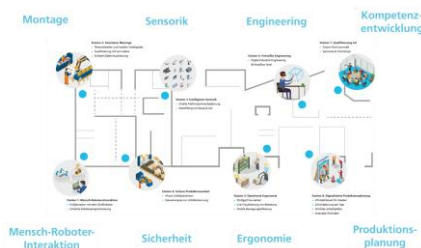
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Learning World of the Future Work Lab
Offers for companies

Developing Competences

Make use of the Future Work Lab for measures of competence development for a series of technologies and topics

Evaluating Competences

We evaluate existing training measures in your company against the background of our experiences on appropriate formats from the Future Work Lab

Readjusting Competence Management

We adjust your current competence management against the background of Industry and Logistics 4.0.

- Which new working tasks occur?
- Which competences become relevant?
- Which competence profiles and gaps occur?
- Which formats of learning can be taken into account?

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http://www.iao.fraunhofer.de

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Backup

World Economic Forum: The Future of Jobs Report 2018
Key findings

- Drivers of change: ubiquitous high-speed mobile internet; artificial intelligence; widespread adoption of big data analytics; and cloud technology

- Accelerated technology adoption

- Trends in robotization: stationary robots, non-humanoid land robots and fully automated aerial drones

- Changing geography of production, distribution and value chains

- Changing employment types

- A new human-machine frontier within existing tasks

- A net positive outlook for jobs

- Emerging in-demand roles

- Growing skills instability

- A reskilling imperative

World Economic Forum: The Future of Jobs Report 2018
Country Profile Brazil

Factors determining job location decisions

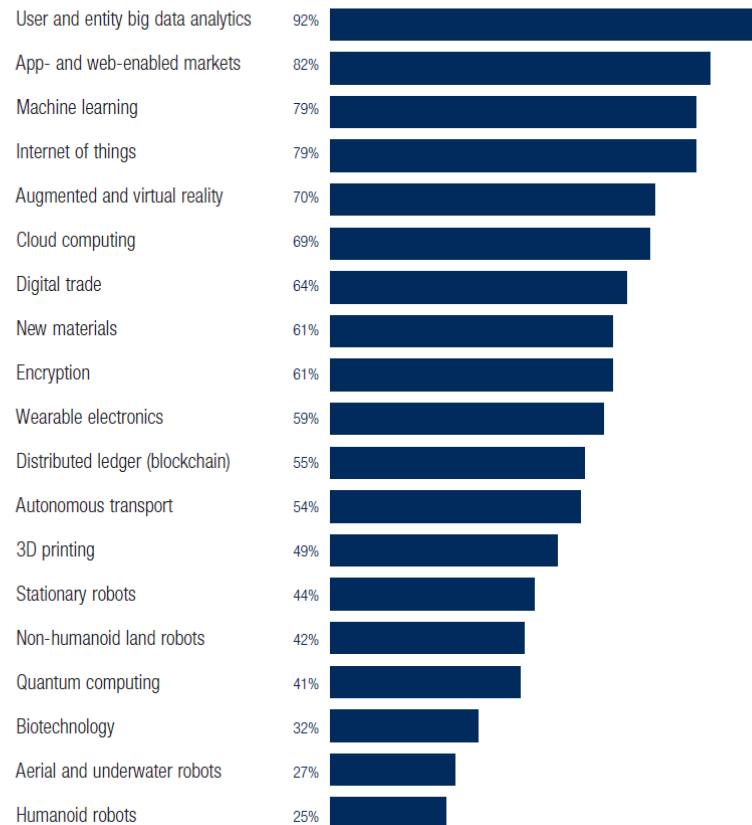| Industry	Primary	Secondary	Tertiary
Automotive, Aerospace, Supply Chain & Transport	Talent availability	Production cost	Labour cost
Aviation, Travel & Tourism	Talent availability	Organization HQ	Ease of importing talent
Chemistry, Advanced Materials & Biotechnology	Talent availability	Labour cost	Production cost
Consumer	Labour cost	Talent availability	Quality of the supply chain
Energy Utilities & Technologies	Production cost	Talent availability	Quality of the supply chain
Financial Services & Investors	Talent availability	Geographic concentration	Organization HQ
Global Health & Healthcare	Talent availability	Labour cost	Production cost
Information & Communication Technologies	Talent availability	Labour cost	Organization HQ
Oil & Gas	Production cost	Talent availability	Organization HQ
Professional Services	Talent availability	Strong local ed. provision	Labour cost

Range of options: Flexibility of labour laws, Geographic spread, Quality of the supply chain, Ease of importing talent, Labour cost, Location of raw materials, Organization HQ, Production cost, Strong local education provision, Talent availability.

Emerging job roles

Software and Applications Developers and Analysts

Managing Directors and Chief Executives

Data Analysts and Scientists

Sales and Marketing Professionals

General and Operations Managers

Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products

Human Resources Specialists

Financial Analysts

Database and Network Professionals

Financial and Investment Advisers

Technology adoption *(share of companies surveyed)*

Technology	Share
User and entity big data analytics	92%
App- and web-enabled markets	82%
Machine learning	79%
Internet of things	79%
Augmented and virtual reality	70%
Cloud computing	69%
Digital trade	64%
New materials	61%
Encryption	61%
Wearable electronics	59%
Distributed ledger (blockchain)	55%
Autonomous transport	54%
3D printing	49%
Stationary robots	44%
Non-humanoid land robots	42%
Quantum computing	41%
Biotechnology	32%
Aerial and underwater robots	27%
Humanoid robots	25%

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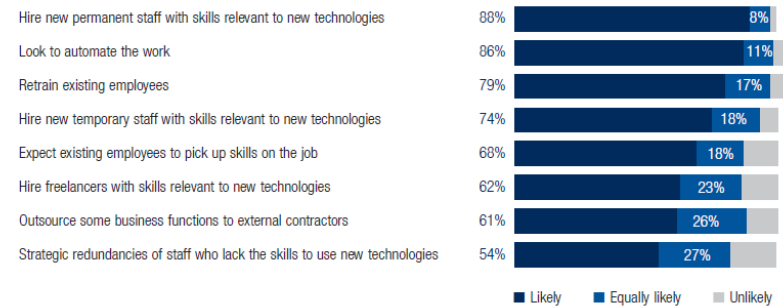IAO

World Economic Forum: The Future of Jobs Report 2018
Country Profile Brazil

Average reskilling needs *(share of workforce)*
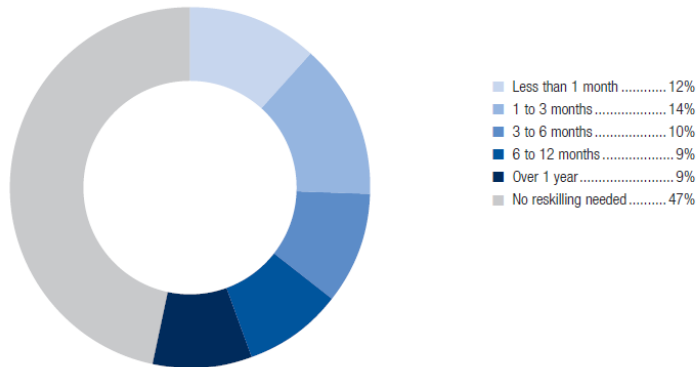
- Less than 1 month 12%
- 1 to 3 months 14%
- 3 to 6 months 10%
- 6 to 12 months 9%
- Over 1 year 9%
- No reskilling needed 47%

Responses to shifting skills needs *(share of companies surveyed)*

	Likely	Equally likely	Unlikely
Hire new permanent staff with skills relevant to new technologies	88%		8%
Look to automate the work	86%		11%
Retrain existing employees	79%		17%
Hire new temporary staff with skills relevant to new technologies	74%		18%
Expect existing employees to pick up skills on the job	68%		18%
Hire freelancers with skills relevant to new technologies	62%		23%
Outsource some business functions to external contractors	61%		26%
Strategic redundancies of staff who lack the skills to use new technologies	54%		27%

Emerging skills

- Analytical thinking and innovation
- Creativity, originality and initiative
- Active learning and learning strategies
- Technology design and programming
- Reasoning, problem-solving and ideation
- Leadership and social influence
- Critical thinking and analysis
- Complex problem-solving
- Resilience, stress tolerance and flexibility
- Emotional intelligence

Projected use of training providers *(share of training)*

Internal department	48%
Private training providers	28%
Private educational institutions	18%
Public educational institutions	16%
Public training provider	12%

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Country Profile Germany

Factors determining job location decisions

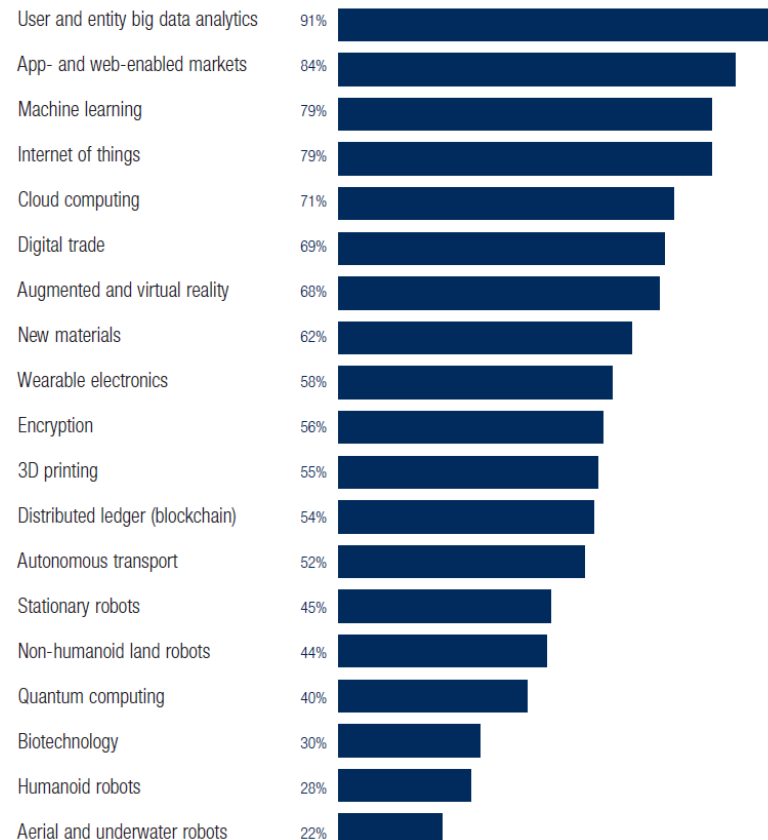| Industry	Primary	Secondary	Tertiary
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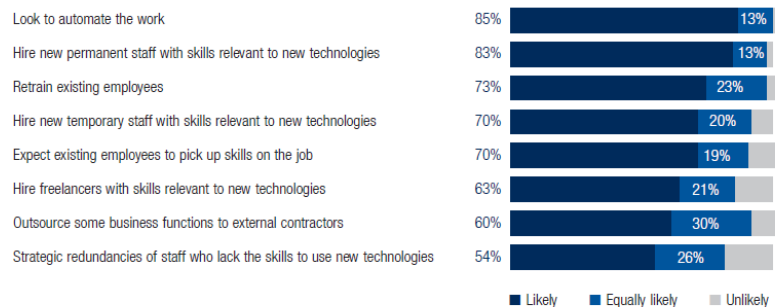| Technology	Share
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World Economic Forum: The Future of Jobs Report 2018
Country Profile Germany

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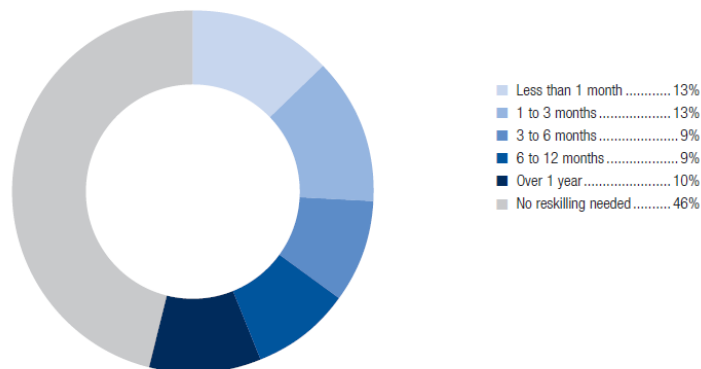
Less than 1 month	13%
1 to 3 months	13%
3 to 6 months	9%
6 to 12 months	9%
Over 1 year	10%
No reskilling needed	46%

Responses to shifting skills needs *(share of companies surveyed)*

	Likely	Equally likely
Look to automate the work	85%	13%
Hire new permanent staff with skills relevant to new technologies	83%	13%
Retrain existing employees	73%	23%
Hire new temporary staff with skills relevant to new technologies	70%	20%
Expect existing employees to pick up skills on the job	70%	19%
Hire freelancers with skills relevant to new technologies	63%	21%
Outsource some business functions to external contractors	60%	30%
Strategic redundancies of staff who lack the skills to use new technologies	54%	26%

Legend: ■ Likely ■ Equally likely ▢ Unlikely

Emerging skills

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Active learning and learning strategies
Technology design and programming
Critical thinking and analysis
Complex problem-solving

Leadership and social influence
Emotional intelligence
Resilience, stress tolerance and flexibility
Systems analysis and evaluation

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