A New Paradigm of Human-Machine Collaboration

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A Joint German-Japanese Project

Plattform INDUSTRIE 4.0

2013

…will radically transform jobs and competence profiles

→ **life long learning**

→ **new design of workplace and HMI**

Society 5.0

2017

…creating a society where we can resolve various social challenges

→ **How will introduction of AI etc. change workplaces?**

→ **Similar social challenges** (aging population, skills shortage, increasing diversity)

→ “**historical background** and **social structures** influence our approach”

HMI

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Digitalization: The German Approach

Strategic Projects of the German Government (2011 – 2017)

2011 – 2013

Industrie 4.0

- IT/OT-Convergence
- SmartX, Ad-hoc connectivity, decentral

AI HMI

Rethink production processes and workplaces

2013 – 2018

Smart Service Welt

Smart Service Welt

- Business model of the digital economy
- XaaS, data driven, platform based

AI HMI

Rethink business models and ecosystems

2015 – 2017

Autonome Systeme

- At home, at work, on the way
- XBots & ‘moral algorithms’

AI HMI

Rethink social, legal, and ethical implications

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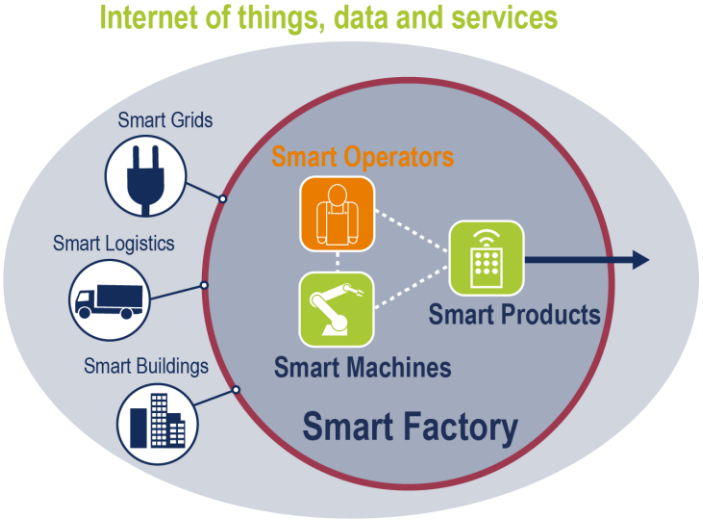
Paradigm Shift I: Industrie 4.0

Individual Products Under the Conditions of Mass Production

- **Smart Products:** Actively support production processes
- **Smart Operator:** Digital assistance systems support employees
- **Smart Machines:** negotiate independently
- **Hybrid teams:** Robots become co-workers
- Increasing complexity: **Decentralized, connected autonomous systems**



→ Goal: Agile, Learning and Adaptable Factories

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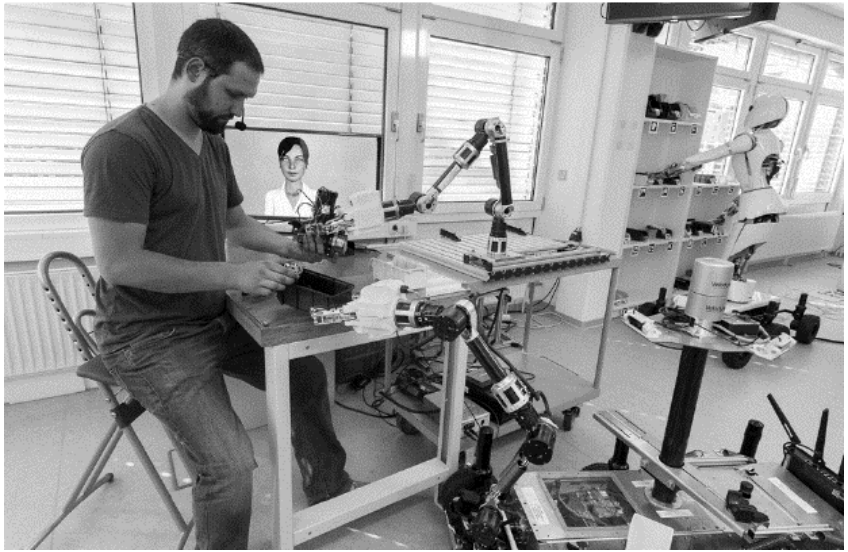
Future of Work and Human-Machine Interaction

Case-Study in Germany: Hybrid Teams



- **Hybrid teams:**
  - Humans (supported by augmented reality)
  - Autonomous robots and virtual agents (softbots) as partners
- **Joint problem solving:**
  - Work sharing according to specific capabilities
- **Self-reorganization:**
  - In case of unexpected incidents

→ Robots have to adapt to human‘s behavior.

Source: Wahlster (2017): Künstliche Intelligenz als Grundlage autonomer Systeme

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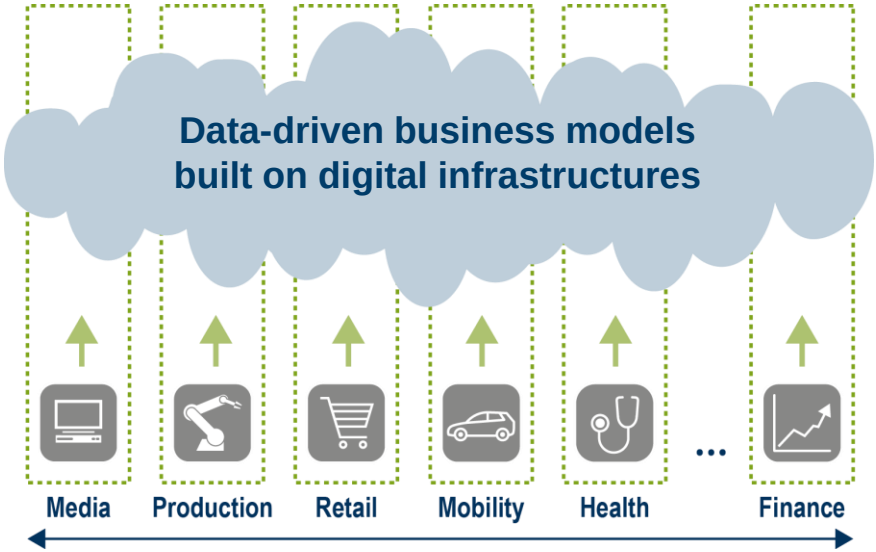
Paradigm Shift II: The Users at the Centre

…in their Respective Roles as Employees, Consumers, Citizens



- Smart Services:
  - **Personalized** and **designed to fit** the respective situation using **Smart Data**
  - '**On demand**'
  - → **Across different industries**
- Requirements:
  - Semantic **interoperability** (machine-understandable data)
  - Methods and tools of AI (**Machine Learning**)

→ Smart Services are created in digital ecosystems.

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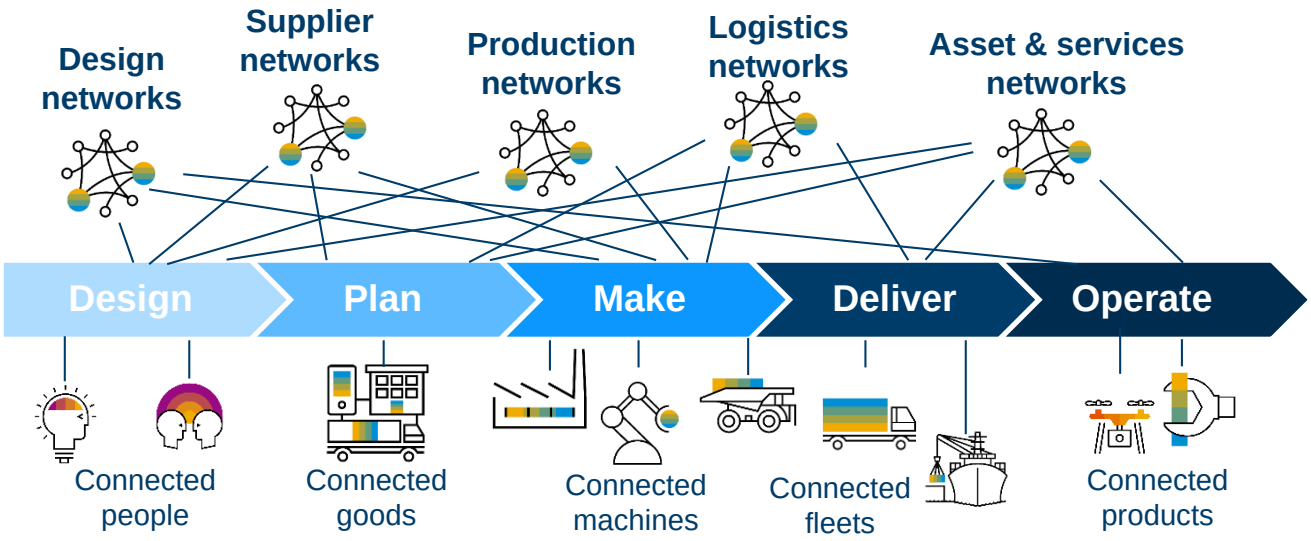
Business Networks & Autonomous Systems Become Extensions of ERP

Networks:
- Collaboration
- Behavior based work

Autonomy:
- Routine work
- Edge computing



→ Processes break up into automated task and behavioral work.

Source: SAP SE

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A New Wave of Business Process Transformation Due To Emerging Symbiosis Between Man & Machine

From **standardized** and **automated** (RPA) processes to **adaptive** processes

→ **Platforms, ecosystems, smart talents**

Create	*Judge*	*Lead*	*Train*	*Explain*	*Amplify*	*Interact*	*Transact*	*Iterate*	*Predict*
			Humans complement		Machines complement				
Human-only			**Hybrid**				**Machine-only**		

→ **Collaborating teams of humans work alongside with machines**

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Emerging New Challenges
Due To Increasing Use of Autonomous Systems

H. Kagermann (President, acatech),
S. Abe (Prime Minister, Japan),
A. Merkel (Chancellor, Germany)

- Autonomous systems independently achieve **predefined goals**
  → Situational adaptability
- Potential to solve the **major social issues**
- New **social, legal & ethical challenges**
  → Gradual and experience-based introduction via **use cases**
  → Promotion through the early establishment of a broad-based **public dialogue**

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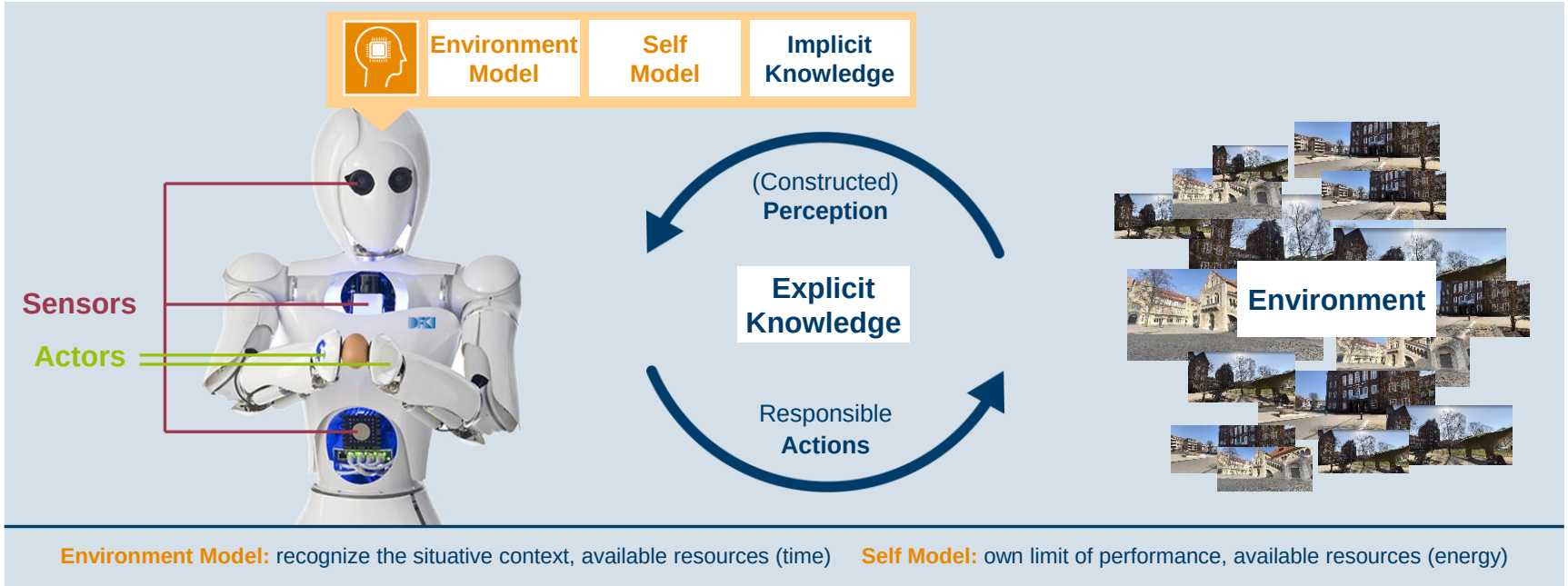
Basic Principles of Autonomous Systems



Environment Model: recognize the situative context, available resources (time) **Self Model:** own limit of performance, available resources (energy)

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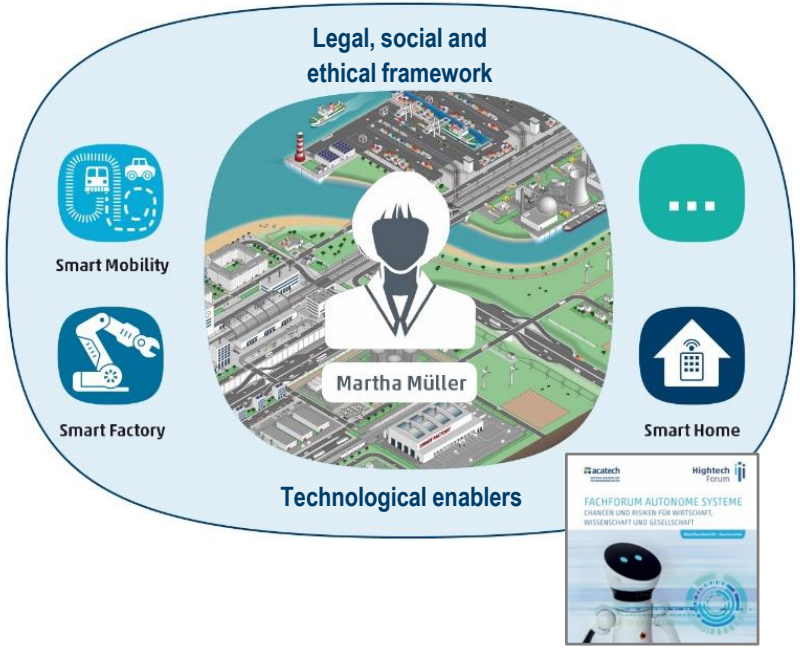
A Holistic Approach is Necessary



- People will encounter autonomous systems **on a daily basis**: at home, on the move, at work …
- Areas of application can **no longer** be viewed **in isolation**.

  → Consistent **human-technology-interaction**

  → Consistent **safety levels**

  → Consistent **legal / ethical rules**

Source: Fachforum Autonome Systeme im Hightech Forum (2017): Autonome Systeme

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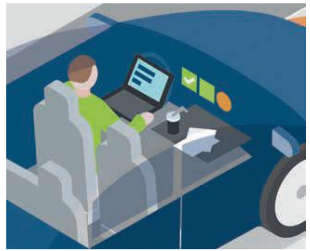
Example: Highly Automated Driving
Challenge: Human-Machine Interaction

- Complete **documentation**: Who is in control (and when)?
- Controlled **handover**: Is the buffer time enough?
- **Overruling I:** May the system reject a handover request?
  - Limited fitness to drive (fatigue etc.)
  - System error: Human is willing to take corrective actions
- **Overruling II:** May the system take control?
  - Driver deliberately steers towards a crowd (terrorist attack)
  - Driver violates traffic rules (paternalism?)



→ Balancing overall safety of the traffic system against individual freedom

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acatech DISCUSSION: Revitalizing Human-Machine Interaction
Supported by RRI and Platform Industrie 4.0

- **Japan** and **Germany** have similar **societal challenges**, e.g. maturing workforce, aging machines and infrastructure
- In order to **solve** these **problems**, they increasingly **rely on digital technologies** (e.g. CPS, AI, and robotics)
- **HMI** plays a **central role** in this process, due to the increasing **intertwining** of **natural** and **artificial intelligence**
- The **countries' solutions differ** as a result of diverging **societal trends** & **culturally related** problem-solving **approaches**

→ **Clarification and highlighting of similarities and differences and identifying common areas of cooperation for future German-Japanese initiatives**

The Future of Employment
A German and Japanese View

- A **decrease** in the **working population** has already begun that implies **social challenges**.
- Japan and Germany need to **increase** their **labor productivity** by **improving human skill sets**.
- As **technology progresses**, **more routine manual and cognitive tasks** will be **replaced** by machines.
- But **digitalization** may help to **offer** employees more **high-value-added jobs**; the **society** must **support** the changes.

Germany

Common understanding of all stakeholders:

- **Need for agile work and lifelong learning**
- **Potential to improve work attractiveness, employability and work-life balance**
- **advantages** of **human-centered**, **hybrid teams**

driven by the implementation of Industrie 4.0

Japan

The **separation of tasks** has begun that implies a process of substitution:

- First, mostly **routine work** is **substituted** by machines → **humans** are then **motivated** to **create** further **machines**
- As more machines are introduced, **humans** are **required** for **highly skilled work** → companies invest in HR-development
- The **rate** of **machines introduction increases** → managers start to **replace humans** and layoffs commence
- **Humans must train** by **themselves** during their **entire lifetime**

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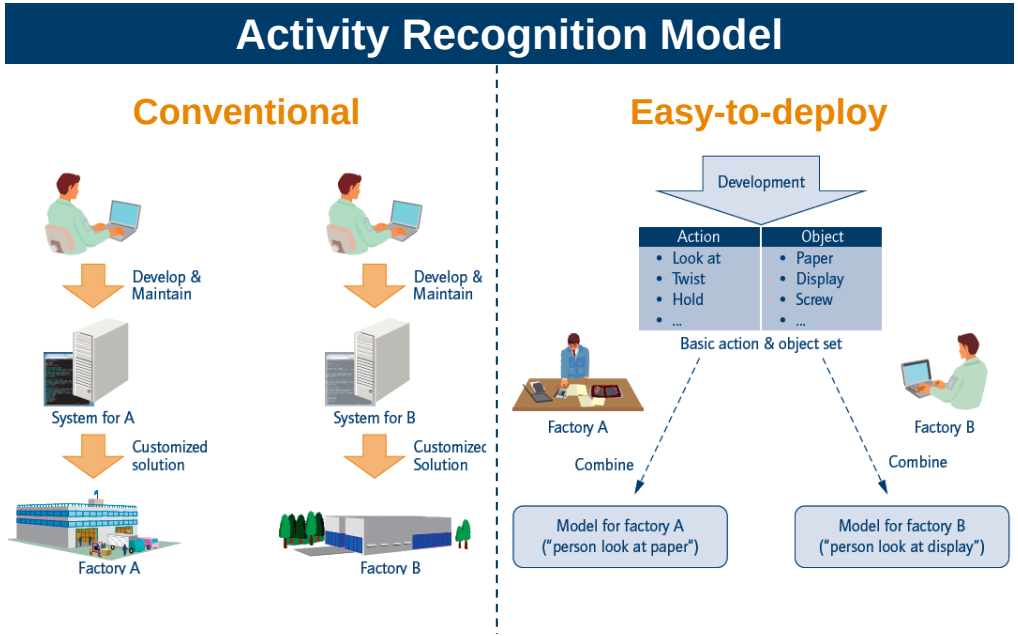
Transfer Knowledge Efficiently Between Machines, Experts and Beginners



- **Worker** (either human or machine) **activity recognition** can play a **vital role**.
- **Conventional methods create separate recognition models**, because of the diversity of activities and their representation.
- The **goal:** An **easy-to-deploy human-activity recognition model**, which can be **applied** to **different factories** as a **standard solution** at a low cost.

Source: DFKI

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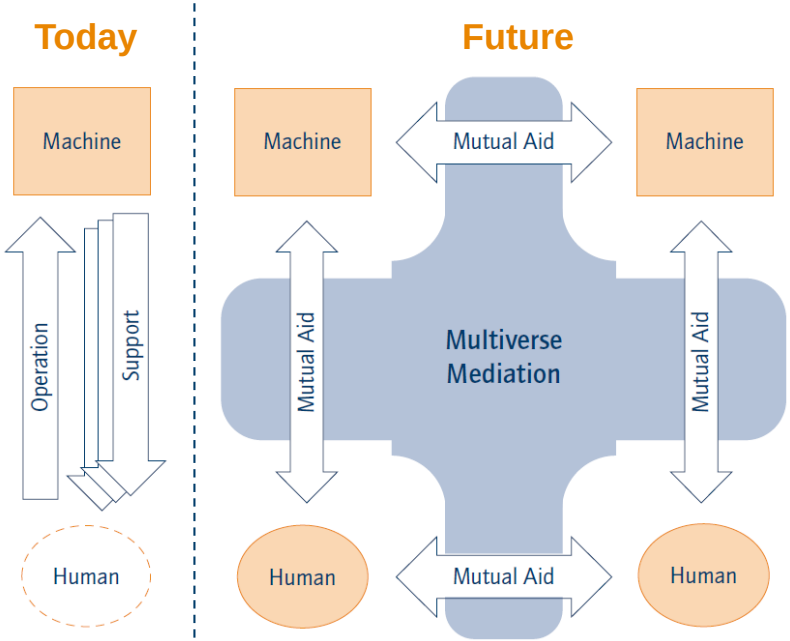
The Transition of Interaction Models



- **Sustainable economic growth** requires that **humans** find **fulfillment** in their work while **evolving hand in hand** with **machines**.
- **Today's model: machines assist humans**. Less training required for humans.
- **Future model: harmonizing HMI**
  - Observe all interactions
  - Digitize and accumulate observations
  - Identify potential improvements
  - Systematically adjust the capabilities of both humans and machines

Source: Own presentation based on Hitachi

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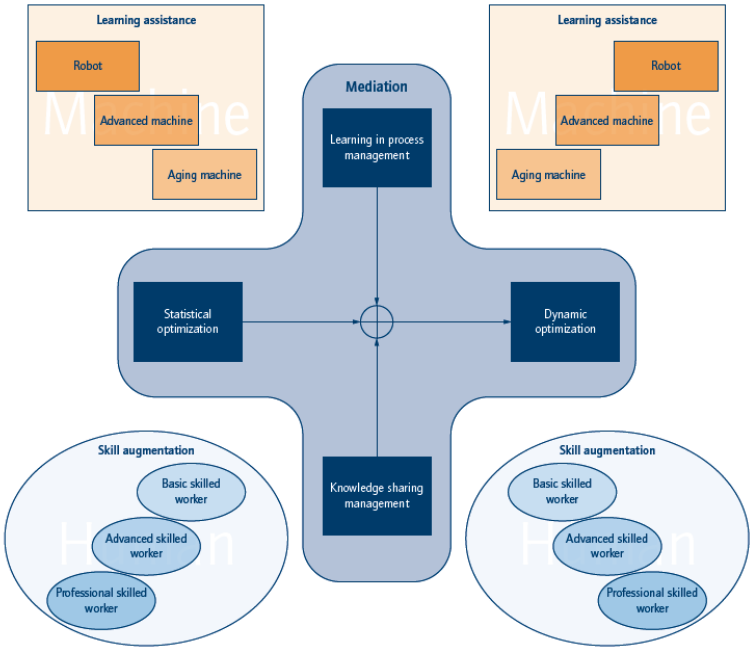

Source: Own presentation based on Mitsubishi Electric Corporation

- In a **workplace**, where the new model is introduced employees must become skillful in dealing with
  - **statistical optimization**
  - **dynamical optimization**
  - **learning in process**
  - **knowledge sharing management**

  supported by digital technologies.
- **Enterprises** should **embrace** the **new paradigm** of **human-machine collaboration**.

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Conclusion

- **Digital technologies** are expected to help **solve social challenges**.
- The **digital transformation** can **enable** a novel, **human-centered manufacturing system** that **revitalizes HMI.**
- A **new HMI model** – a **social mediation process** that **adjusts** for **mutual support** – is under development.
- It is necessary to **share experiences** at **various levels**, such as factory, company, country, world, etc.
- We have **recognized similarities** and **differences among** the **two countries** on how to deal with the issue at hand.
- We **encourage keeping discussions open among multiple countries** in the effort to **establish** a **sustainable society**.

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Project Team & Download Link

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PDF

https://en.acatech.de/publication/revitalizing-human-machine-interaction-for-the-advancement-of-society-perspectives-from-germany-and-japan/

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This German-Japanese Project was supported by members of the Research Council of the Plattform Industrie 4.0

30 **science and industry representatives working together** on the following tasks:

- creating **scientific, research-based recommendations**
- realizing **knowledge transfer**
- provision of **new**, **pre-competitive research questions**

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RESEARCH COUNCIL

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Thank you very much for your attention.

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Key Success Factor Cultural Change

- **Organizational agility:**
  - Ambidexterity (two operating systems – one organization)
  - Creating space for experiments
  - Decentralized decisions
  - Self-determined and flexible work
- **Lifelong learning:**
  - Flexible, participative, in networks
  - Increasingly personalized and on-the-job
  - Using digital learning methods
- **Educational institutions:**
  - Strengthening the transfer as “third mission”

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