5G meets Industrie 4.0

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The Mobile Story

- **Bigger than Hollywood**
  - IOS app business surpassing movie theater ticket sales
- **Mobile is eating the world … and itself**
  - 4 bn people buying phones every two years, 50% of global internet traffic, 50% of consumer electronics sales, …
- **5G for verticals**
  - Looking for new opportunities; targeting ongoing Make or Buy discussions
- **More than just Olympics**
  - Not only higher data rate, higher frequencies, lower latency, better energy efficiency but also enabling new business, reducing service creation time, providing forward compatibility, offering more flexible deployment strategies, …
- **„Cannot wait“ might have to wait**
  - Costs versus business opportunity trade-off needs to be understood.
- **Design follows business**
  - What will 5G deliver to the verticals … network slieces, trust zones (edge clouds), …
- **Start of something …**
  - Is 5G just the next generation, or the last one, will there be a nationwide 5G roll-out, …

The 5G Users

- **Kids watching videos (50% of mobile traffic, still growing).**
- **…**
- **Railways:** 300 Mb/s per train, 95% time availability.
- **Broadcast (DVB):** 240 Mb/s with 95% of areas covered.
- **PPDR:** 2 x 10 Mb/s plus 10 Mb/s DL, deep indoor (+ 15 dB), security, group calls, push to talk, high availability
- **Railways GSM-R / ETCS:** Erlang 1 per train, 95% availability per every 100 m railway track (EIRENE), group call, functional addressing
- **PMR (taxi, pizza):** broadcast, selective calling, functional addressing, voice and data
- **… telematics, logistics, military networks, audio broadcast …**

5G needs to address their “Make or Buy” discussions.

Who needs 5G?

Broadband access in dense areas

PERVASIVE VIDEO

Broadband access everywhere

50+ MBPS EVERYWHERE

Higher user mobility

HIGH SPEED TRAIN

Massive Internet of Things

SENSOR NETWORKS

Extreme real-time communications

TACTILE INTERNET

Lifeline communications

NATURAL DISASTER

Ultra-reliable communications

E-HEALTH SERVICES

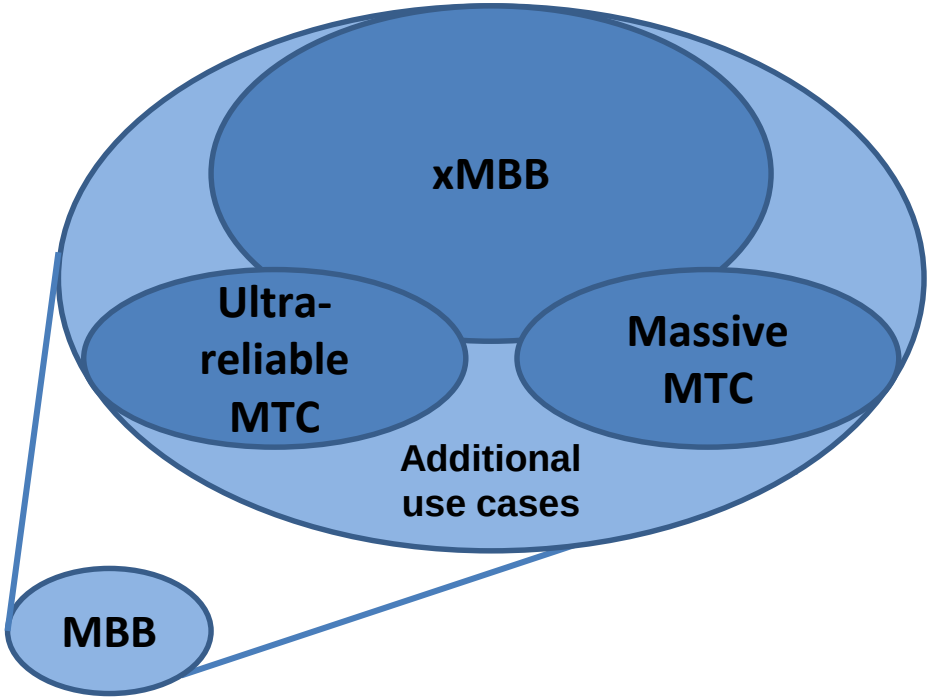
Broadcast-like services

BROADCAST SERVICES

Source: NGMN

5G Main Services

- Extreme Mobile Broadband (xMBB)
  - High data-rates
  - Low-latency communications
  - Improves Quality of Experience
- Massive Machine-Type Communications (M-MTC)
  - Scalable connectivity
  - Wide area coverage
  - Deep penetration
  - Low cost & complexity
- Ultra-reliable/Critical MTC (U-MTC)
  - Ultra-reliable
  - Low-latency
  - E.g., V2X communication and industrial control applications.



5G Zeitplan

2013	2014	2015	2016	2017	2018	2019	2020	2021

PyeongChang 2018

TOKYO 2020

3GPP A GLOBAL INITIATIVE

Rel-13 | Rel-14 | Rel-15 | Rel-16

5G SI(s) | Init. 5G WI(s) | 5G evo

ITU

ITU Requirements | WS | Proposals | Specs

WRC-15 | WRC-19

METIS | 5G PPP (incl. METIS II) | 5G PPP phase 2

IoT, Industrial Internet and Industrie 4.0

- **Internationally competing approaches**
  - Industrie 4.0 program in Germany
    - Driven by and focused on production
    - Initiated by goverment and academia
    - Covering entire product life cycle, RAMI 4.0 reference architecture
  - Industrial Internet Consortiums (IoE Ansatz)
    - Horizontal approach covering several industrial domains
    - Focused on connectivity, IT integration, security
  - Made in China 2025 und Internet Plus
  - Smart Factory (Netherlands), Usine du Futur (France), High Value Manufacturing Catapult (UK), Fabbrica del Futuro (Italy), Factory of the Future (EU)
  - OneM2M (internationale Standardisierung a la 3GPP)
  - …

IoT, Industrial Internet and Industrie 4.0

Industry

Process automation

Production automation

Logistics

Company IT

Industrie 4.0

Energy

Trans-poration & Logistics

Auto-motive

Industrial Internet

5G

Industrie 4.0 versus Industrial Internet

Example: MAPI Foundation

	Industry 4.0	The Industrial Internet Consortium
Key authors	German government	Large multinationals
Key stakeholders	Government, academia, business	Business, academia, government
Taxonomy of revolutions	Four revolutions	Three revolutions
Support platforms	Government industrial policy	Open membership nonprofit consortium
Sectoral focus	Industry	Manufacturing, energy, transportation, healthcare, utilities, cities, agriculture
Technological focus	Supply chain coordination, embedded systems, automation, robots	Device communication, data flows, device controls and integration, predictive analytics, industrial automation
Holistic focus	Hardware	Software, hardware, integration
Geographical focus	Germany and its companies	Global marketplace
Corporate focus	SMEs	Companies of all sizes
Optimization focus	Production optimization	Asset optimization
Standardization focus	On agenda	Recommendations to standards organizations
Economic approach	Normative economics	Positive economics
Overall business approach	Reactive	Proactive

5G meets Industry 4.0

Process Automation

- Mainly monitoring & diagnostics functions
- Characterized by often rather large distances & potentially harsh environments
- First established solutions exist, e.g., WirelessHART, ISA100.11a, ZigBee, etc.

WirelessHART

ISA 100 WIRELESS

Factory Automation

- (Closed-loop) control of manufacturing processes → currently dominated by fieldbusses
- Rotating & moving parts
- Condition monitoring
- Self-guiding products

Source: BOSCH

Production-IT

- Portable monitoring & control devices / HMIs[1] (e.g., tablet PCs, smartphones)
- Augmented reality
- Integration of production facilities in company IT infrastructure (e.g., MES[2])

Source: SAP

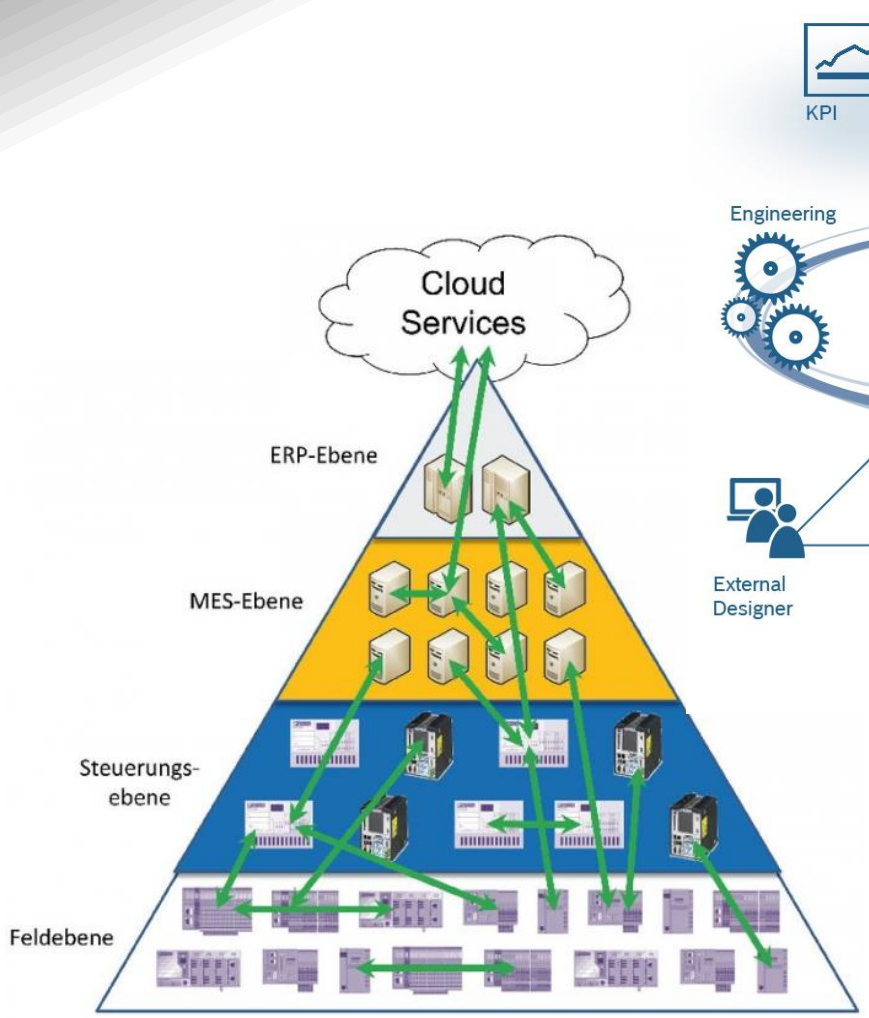
Logistics

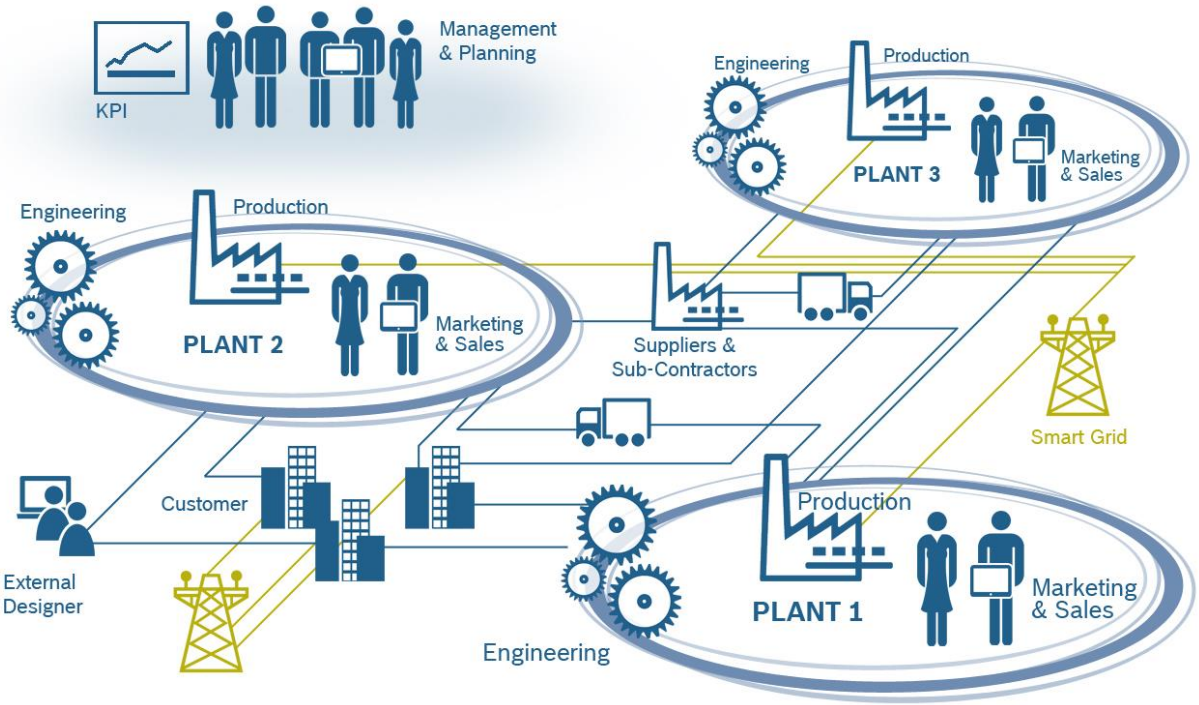
- Mobile service robots
- (Autonomous) transport / cargo units
- Product identification
- Tracking and localization of people & assets

Source: FESTO

Source: Bosch

Industrie 4.0

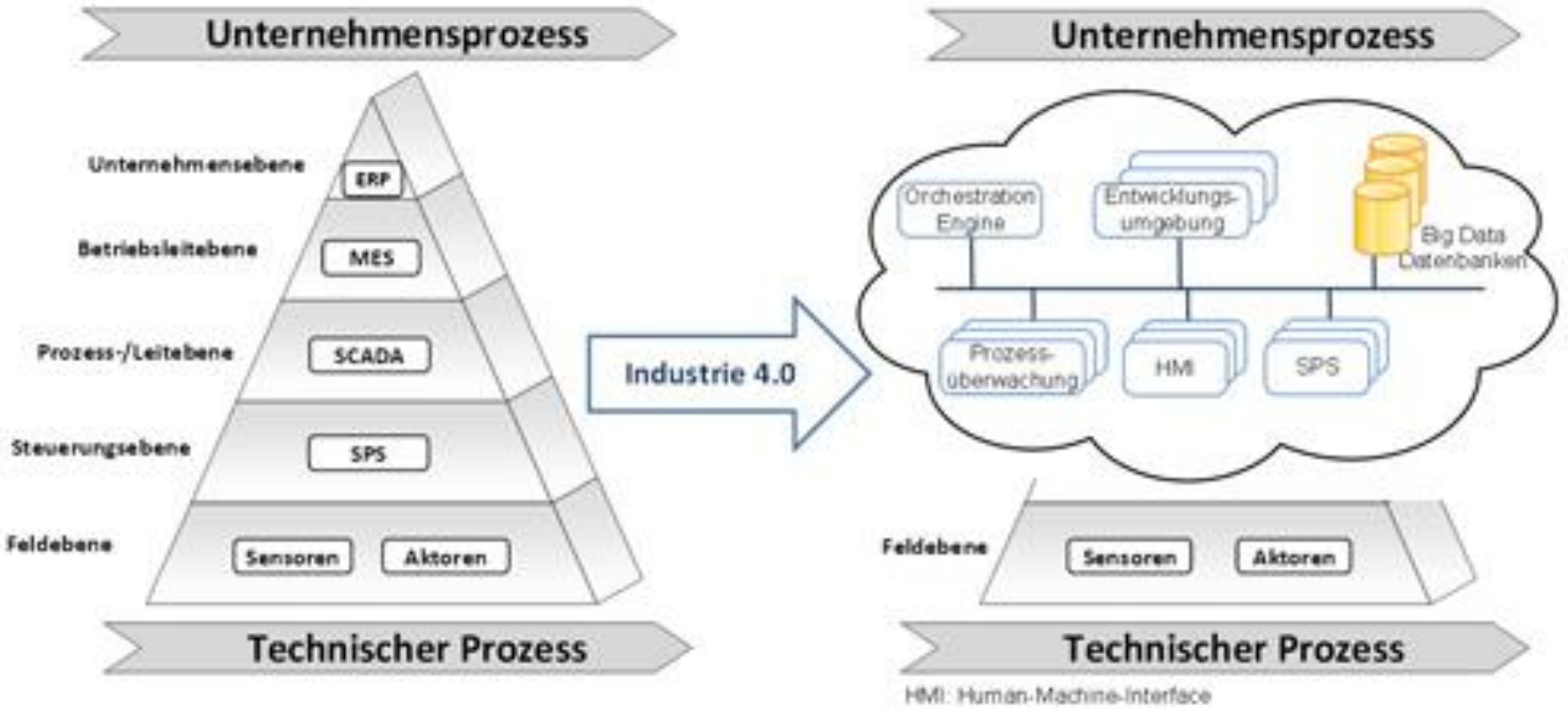




Source: Bosch Rexroth

Source: SPS Magazin

Industrie 4.0



Source: Centrum Industrial IT

Smart Factory Scenario

Massive sensing (MTC)

Factory A

Factory B

Public 4G/5G

Network sliece

Private Cloud

Secure Data center

Network sliece

Internet

Public Cloud

Factory

Trust zones
(edge cloud)

Ultra Low Latency

Control in the
edge cloud
(digital twins)

Remote operation / control
Remote monitoring
Remote assistance
Data analytics

SECURE EDGE CLOUD
SEPERATION LAYER

Integrated High Accuracy Indoor
Positioning

LOCAL VR/AR
Work force

Vendor

REMOTE OPERATION

Industrial Radio

	Closed-Loop Control	Condition Monitoring	Process Automation	HMIs[1] / Augm. Reality
Latency	50 µs… 1 ms, deterministisch	10 ms…> 1 s	5 ms…1 s	down to 1-4 ms
Jitter	≤ ~10 µs, determin.	> 5-10 ms	> 5-10 ms	< 1 ms
Packet loss rate[4]	< 1e-9	< 1e-4	< 1e-4	< 1e-4
Data rate (per node)	up to 100 kbit/s	kbit/s	kbit/s	Mbit/s – Gbit/s
Node density	High	High	Low	Low – Medium
TX Distance	up to 100 m	up to 100 m	up to 1 km	1 m…100 m, multicell
Topology	Star	Mesh / Star	Mesh / Star	Star / Ad-hoc
Bands	2.4 / 5 GHz	2.4 GHz and < 1 GHz		2.4 / 5 / 60 GHz
Energy efficiency	-	> 10 years	> 10 years	> 1 day for HMI
Coexistence	Yes	Yes	Yes	Yes
Mobility support	no	-	-	Yes
Security	Yes	Yes	Yes	Yes
Localization	unclear	-	-	Yes, cm resolution

5G meets Industrie 4.0

Generic requriements

- Usability
- Cost efficiency
- Safety and security, resilience
- Brownfield capability / Backwards and forward compatibility
- Flexibility wrt policies and regulation
- Scalability
- Acceptance in industry ecosystem (what to pay for)
  - Network sliece
  - Trust zone (edge cloud)

  - Remotely managed networks vs interacting network management / control vs autonomous network management

5G meets Industrie 4.0

Specific requriements (examples)

Process automation

- Massive MTC, resilience, interfaces with industrial backbone

Production automation

- Teleoperation (real-time capable network sliece, availability)
- AR tele assistance (real-time capable, broadband network sliece)
- Machines / mobile robots with control in edge cloud (ultra reliable, ultra fast industrial radio, secure edge cloud, localisation, … ➔ spectrum)

Logistics / IT

- Trust zones (edge clouds) supporting implementation of company policies

Open topics

Complexity

- Generic network slices are complex.

Standardisation

3GPP / ETSI / OneM2M vs IEC – partly not perfectly sync‘ed.

Security

- We try to increase reliability and security by softwarisation.

Economic viability of network slices

- Costs of network slieces are not (yet) understood.

Net neutrality

- Can become a major show stopper.

Thank you