



5G Enabled Smart Services for Mobile Robots

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@ SAP Deutschland SE & Co.KG

@ Bosch Rexroth AG

LEADING NEW ICT

5G Test Bed for I4.0 Solutions



Welcome to HUAWEI German Research Center, GRC



Map of Industrie 4.0 use cases Use cases

5G Testbed Adaptive&Connected Equipment

HUAWEI Technologies



Application example Manufacturing industry

Value creation Design & Engineering

Region Bavaria

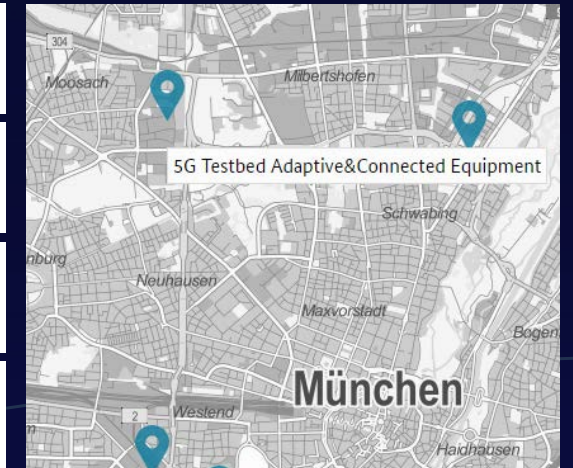
An Industrial 4.0 test laboratory will be set up at the European Research Center of HUAWEI in Munich. The aim is to evaluate a pilot cell of scalable degrees of automation in man-robot collaboration for handling, quality assurance and testing of electronic products.

FESTO

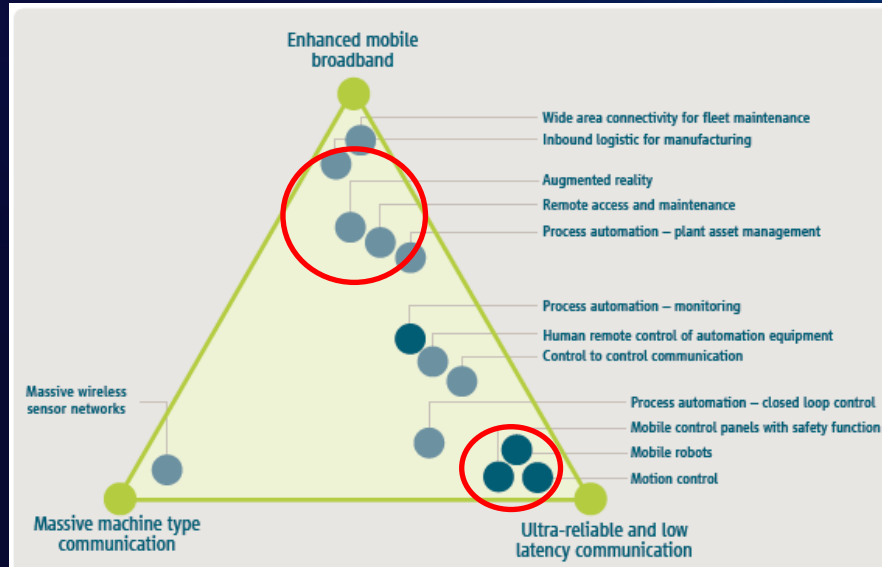
KUKA

ABB

smartFactory



5G Test Bed for I4.0 Solutions



5G will support different performance requirements:

- Peak data rate of up to 20Gbps per connection (eMBB)
- Ultra- reliable and low latency at $< 1\text{ms}$ at $> 99.999\%$ (URLLC)
- Always-on, up to millions of connection per km^2 (mMTC)

PLATFORM
INDUSTRIE4.0



A. Sell

Factory Automation



A. Sell

Adaptive Production, Logistics



A. Sell

VR assisted Assembly

smartFactory

5G Enabled Smart Services for Mobile Robots



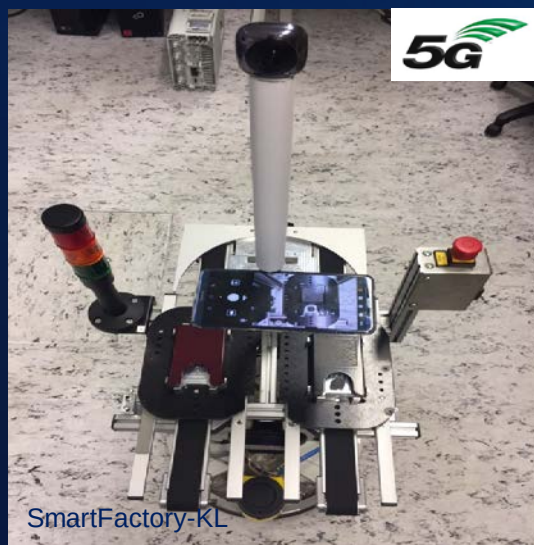
- **5G Capabilities & Services: 4 Use Cases**
 - 1: Motivation and Challenge
 - 2: Architecture of Solution
 - 3: Test Results
- 5G Impact on 4.0 Reference Architecture Model
- Related Activities & Discussion



5G Capabilities & Services addressed in Use Cases



1: Value Creation @ Transport (Infrastructure as a Service: IaaS)



5G Capability	eMBB, mMTC Slicing
Challenge	Use "dead time" Sensor Fusion 5G Robot Ctrl, V.I.
Benefit	Efficiency Gain Spared loc.HW

2: Dynamic Safety & Dynamic Module Certification (IaaS)



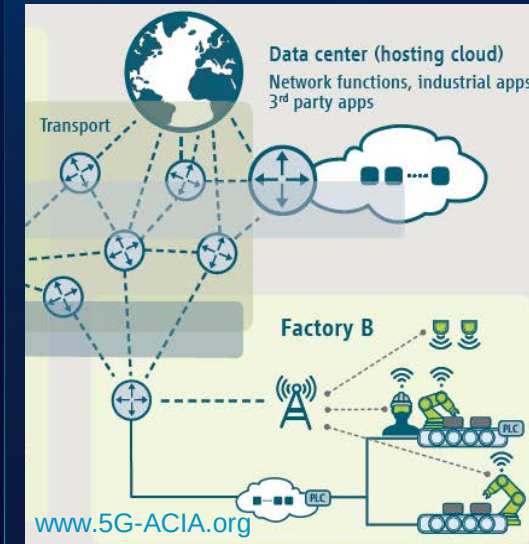
5G Capability	URLLC
Challenge	Neighbourhood Aware Safety, Virt. Risk Models
Benefit	Time Savings, Mobile PROFIsafe

3: PLC in the Cloud Robot as a Service (RaaS)



5G Capability	URLLC
Challenge	Tactile Feed-back 5ms (RTT) PLC in the Cloud
Benefit	RAAS, Reduced HW complexity

4: Network Management Service: "Slicing"

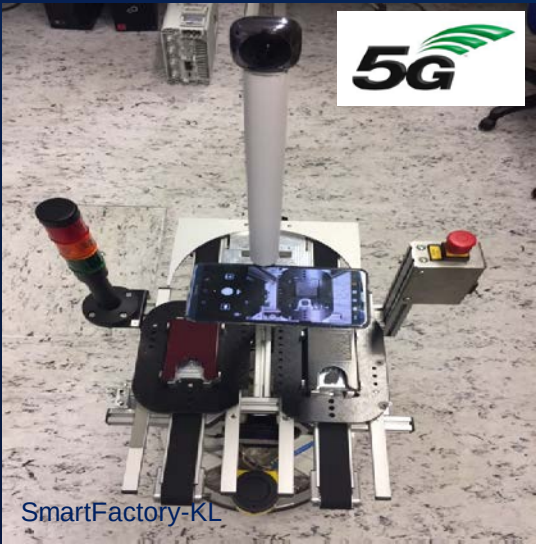


5G Capability	Slicing for Virtual NWs
Challenge	Provide multiple Logical NWs for 14.0 Applications
Benefit	Appl run on one Infrastructure

Use Case 1: “Value Creation @ Transport ” -IaaS

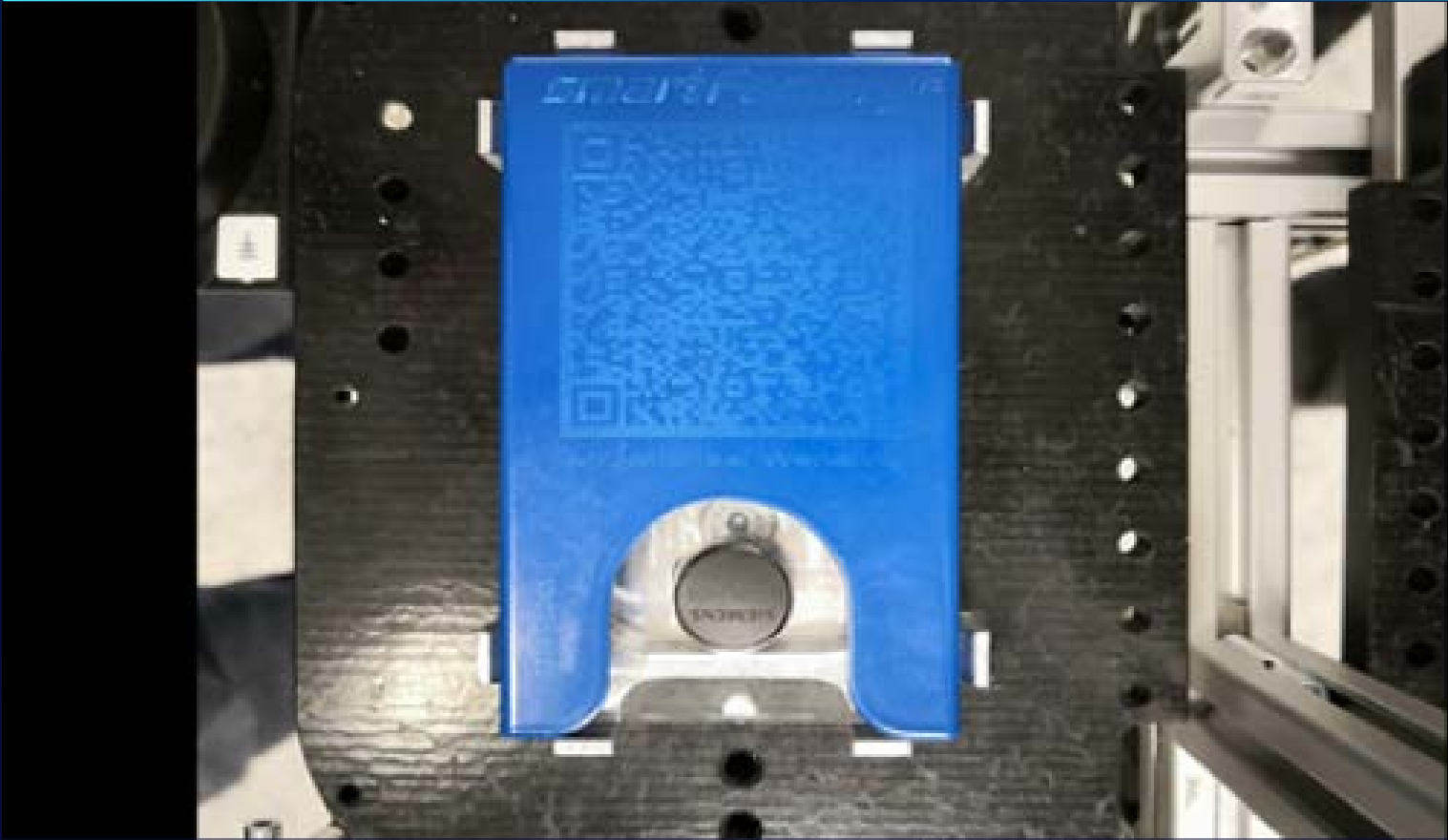


1: Value Creation @ Transport (Infrastructure as a Service: IaaS)



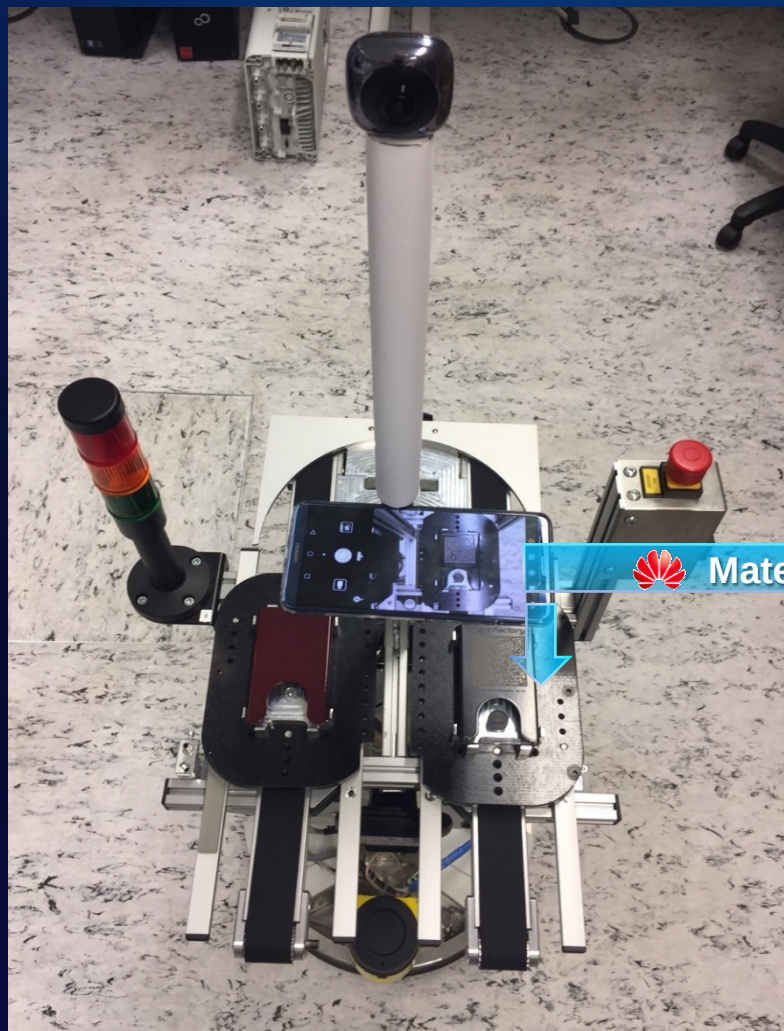
5G Capability	eMBB, mMTC Slicing
Challenge	Use “dead time” Sensor Fusion 5G Robot Ctrl, V.I.
Benefit	Efficiency Gain Spared loc.HW

Product Transport & Quality Inspection: Product Variants @ Different Process Stages
- Compliance Check: Spring Presence, Colour, QR-Code, Assembly State -



Sensor for Retrofitting the Robot

5G terminal for Data transmission



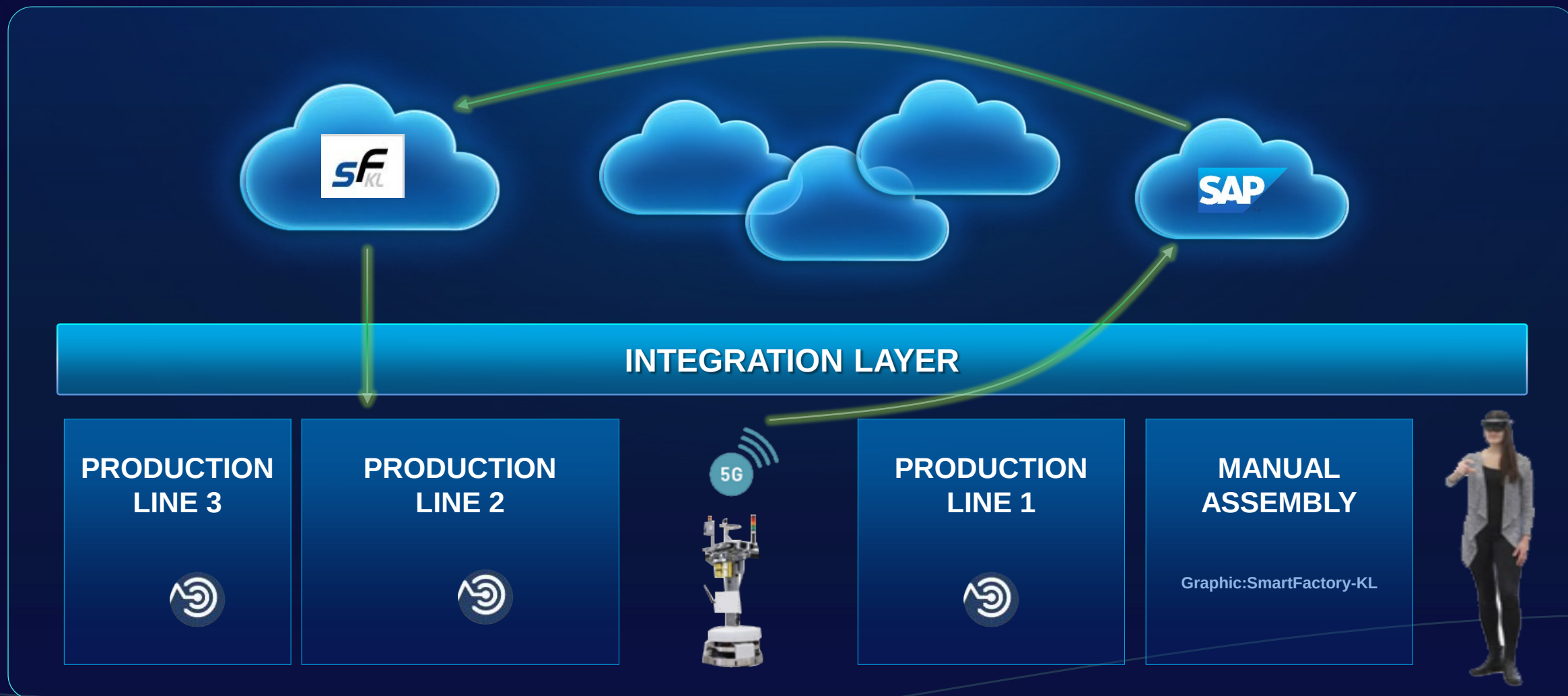
RFID-Product Memory Product Leica Camera:
12 MPixel (3968x2976)



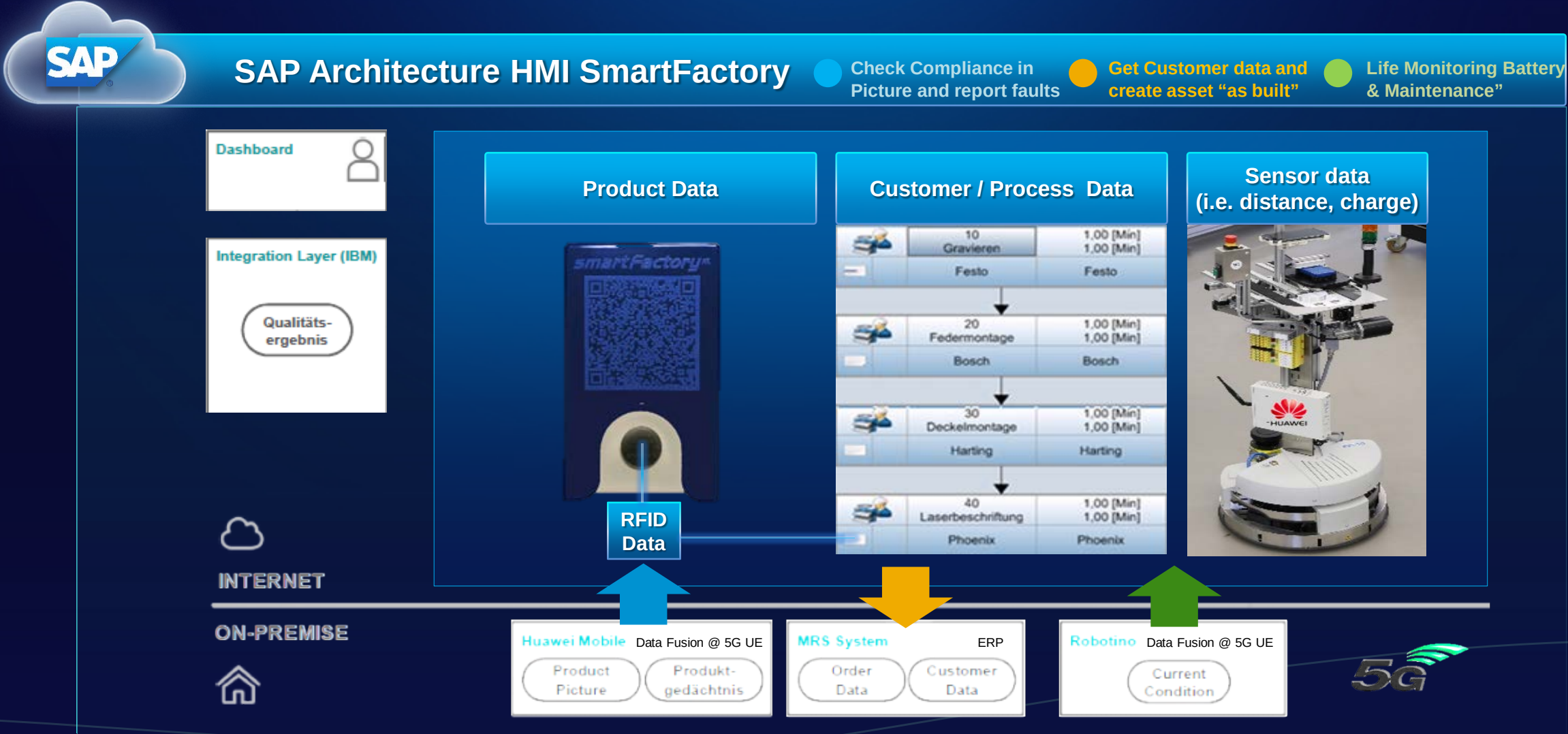
Quality Dashboard / Result from Cloud to
operator's Smartphone



General Architecture of Use Case 1



Cloud Service & Data Flow

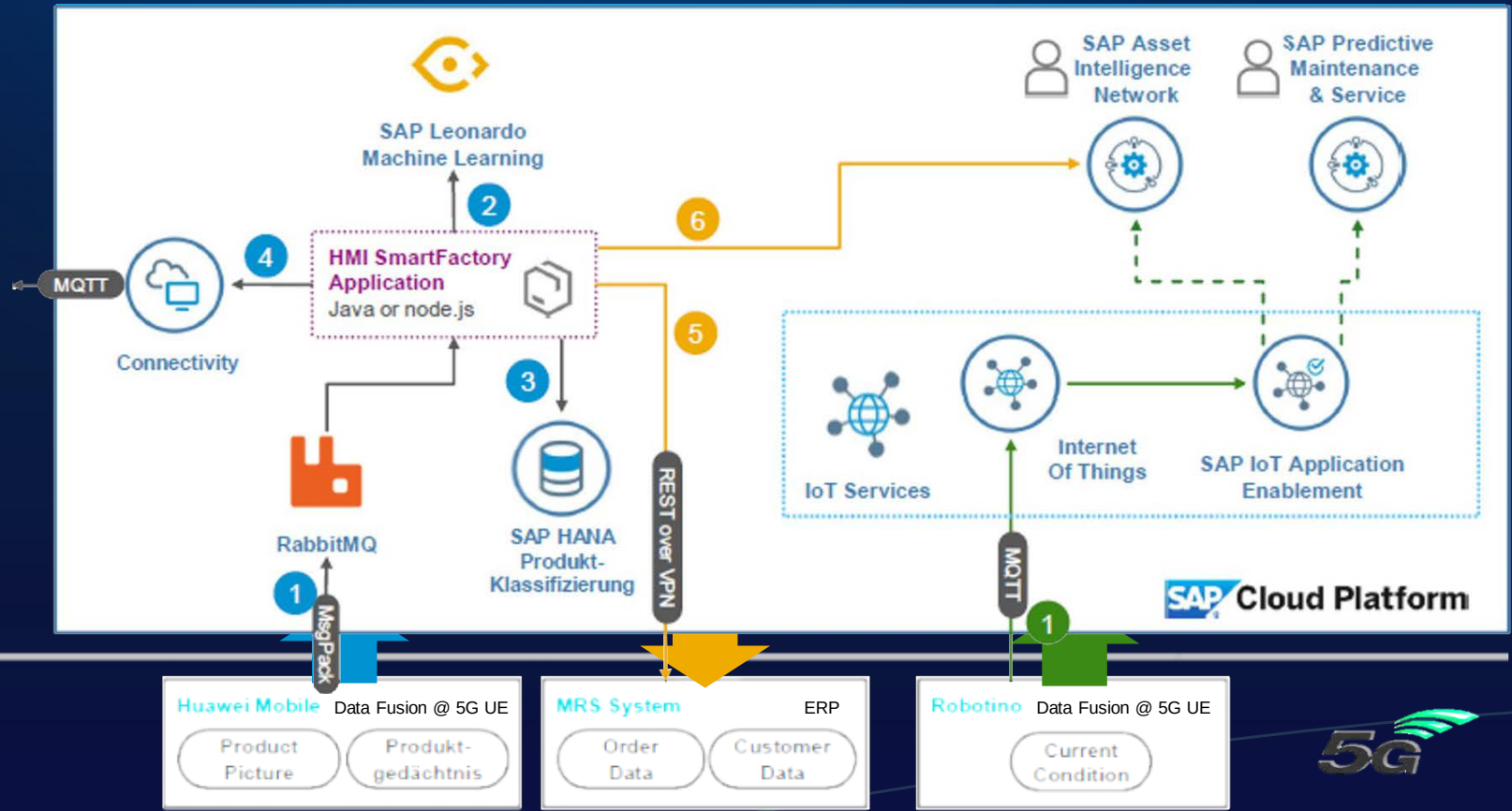


Cloud Service & Data Flow



SAP Architecture HMI SmartFactory

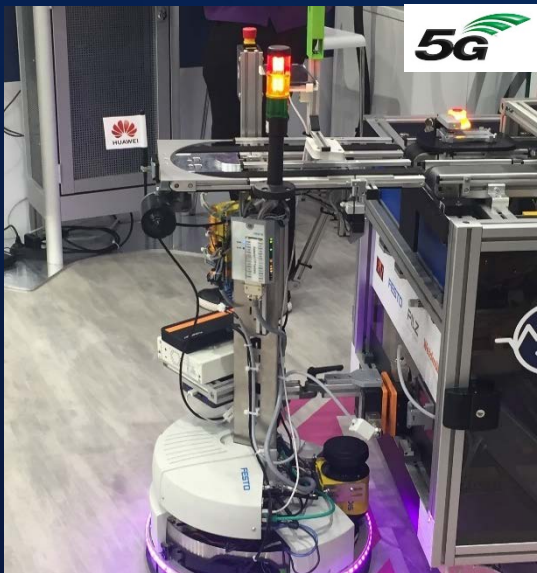
- Check Compliance in Picture and report faults
- Get Customer data and create asset "as built"
- Life Monitoring Battery & Maintenance"



Use Case 2 “Dynamic Safety & Module Certification (IaaS)”



2: Dynamic Safety & Dynamic Module Certification (IaaS)



5G Capability	URLLC
Challenge	Neighbourhood Aware Safety, Virt. Risk Models
Benefit	Time Savings, Mobile PROFIsafe



Use Case 2 “Dynamic Safety & Module Certification (IaaS)”

Technology Features

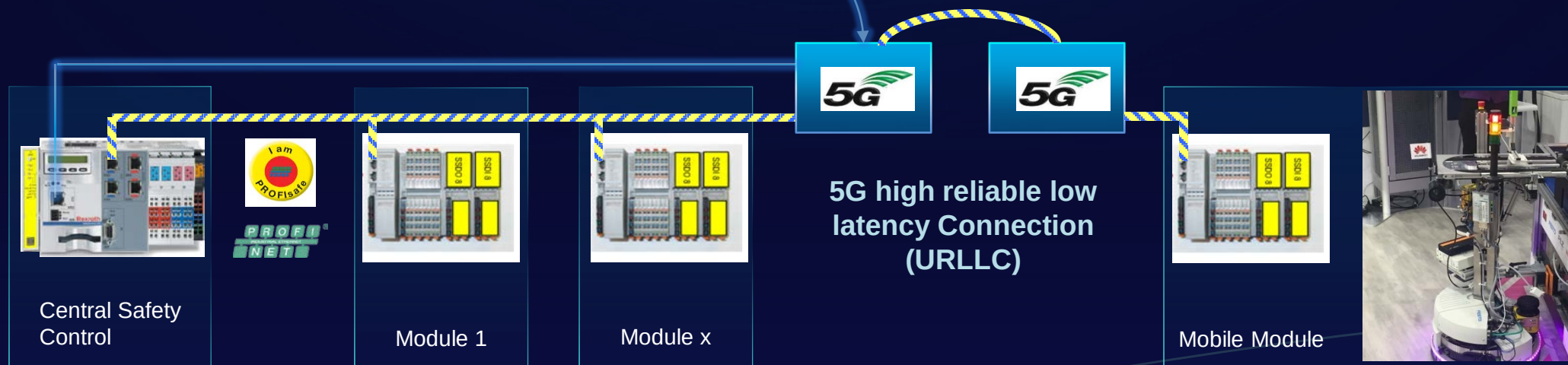
- Transport Safety protocols over a 5G slice
- Deploy cloud based services for machine verification

Safety relevant
machine verification as
Cloud Services

Rexroth
Bosch Group

User Benefit

- Reliable wireless transport layer for fieldbus and safety protocols
- Fast machine reconfiguration with automated safety verification



Rexroth
Bosch Group



pilz

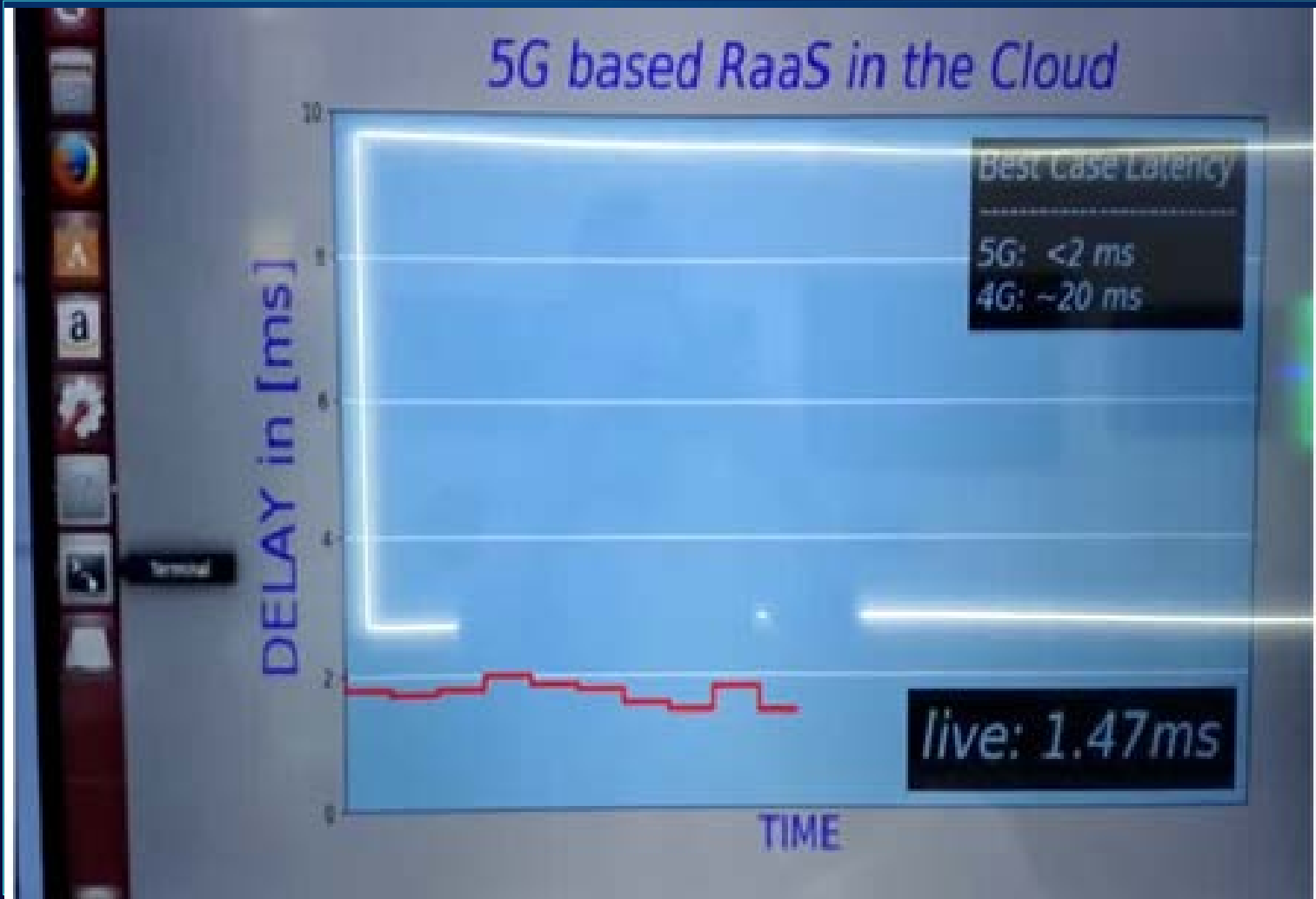
Use Case 3 “Robot as a Service (RaaS) - PLC in the Cloud”



3: PLC in the Cloud Robot as a Service (RaaS)



5G Capability	URLLC
Challenge	Tactile Feed-back 5ms (RTT) PLC in the Cloud
Benefit	RAAS, Reduced HW complexity



Use Case 3 “Robot as a Service (RaaS) - PLC in the Cloud”



Real time closed loop with 5G New Radio (5G NR)



- Control functions runs on an factory cloud connected via 5G
- Simplifies robot design
- Challenge for real time: “balancing”

Benefit of RaaS:

- Savings for spared hardware
- Computing complexity in the cloud
- Reuse of data for new services

5G enables cloud based processing of deterministic control with cycle time of 1ms

Architecture of Use Case 3 - Real Time Closed Loop Control with 5G New Radio



Robot as a Service (RaaS)

- Proof low latency radio communications for real time control loops
- Control functions run on a factory cloud connected via 5G
- Tactile real time Feedback: balancing a ball on a tablet

Challenge

- Varying packet size
- Latency requirements < 2ms, RTT 5ms
- Fast control calculations in the cloud



Moving Robot

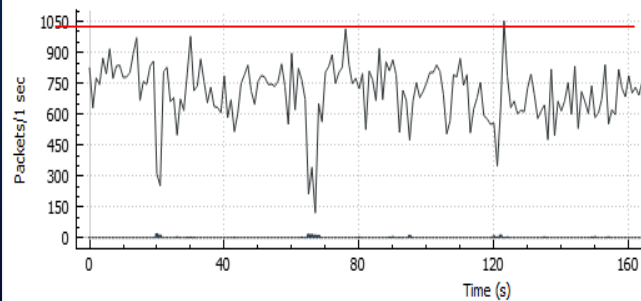


Test Result RaaS - Data rate and package statistics

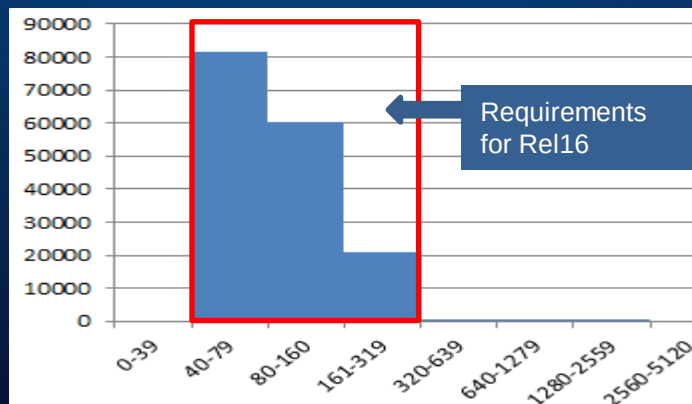


Time Variation of packet size

Packet transmit frequency 1 kHz



Histogram of Packet Length



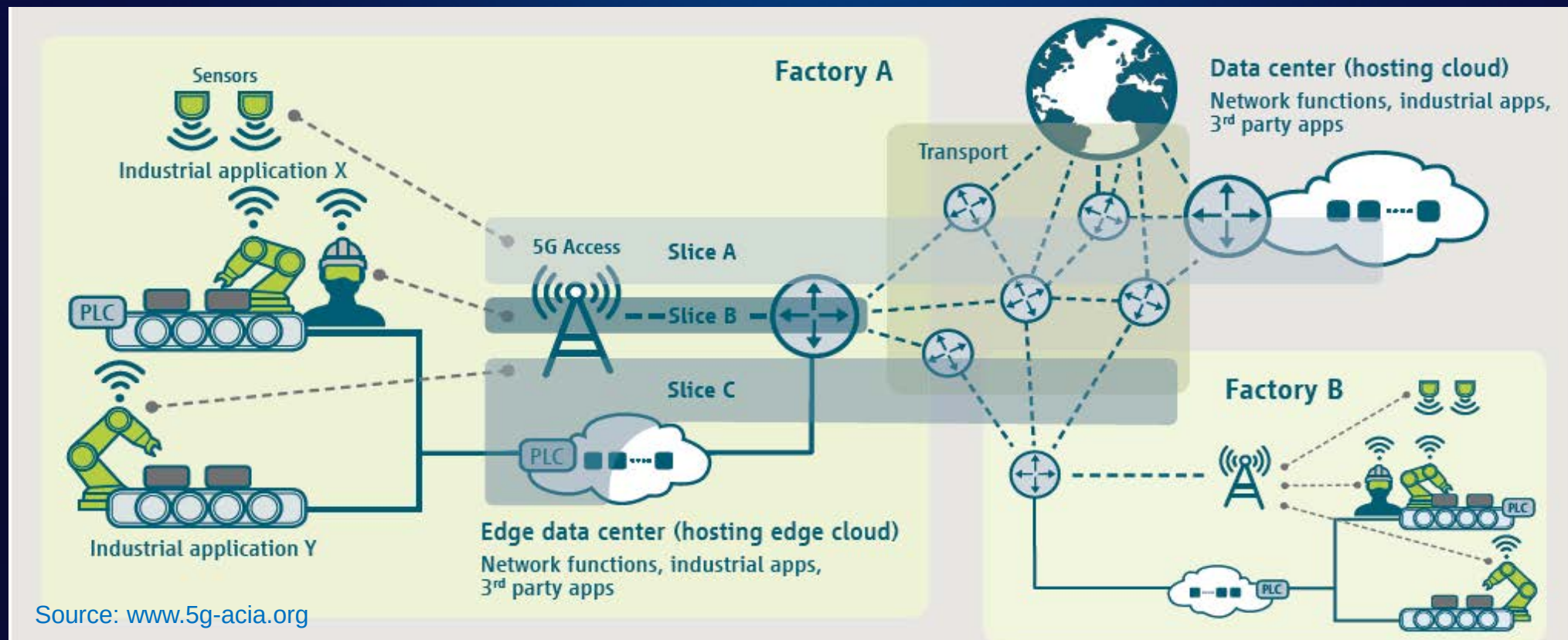
TTI: Transmission Time Interval
URLLC: Ultra Reliable Low Latency Communication

1000 data packets transmitted each second $\rightarrow$ 1/ms
Retransmissions to guarantee reliability ($>>99.9999\%$)
 $\rightarrow$ Short TTI of <250 ms
 $\rightarrow$ Already agreed in 5G (3GPP Rel 15)

Packet size mostly 40-320 byte
5G URLLC as defined in Rel15 (3GPP) support 32 byte
 $\rightarrow$ update requires of URLLC in 3GPP Rel 16
 $\rightarrow$ PolarCodes for optimized support of short packet sizes



Use Case 4 “Network Management Service: “Slicing”



Technology Features

- Multiple Isolated Networks
- Shared Physical Infrastructure
- E2E Rules for Cross Domain Service Guarantees

User Benefit

- Application Tailoring
- Short Service Creation Time
- Guaranteed SLA

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5G Capabilities & Services: 4 Use Cases

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5G Impact on 4.0 Reference Architecture Model

Related Activities & Discussion

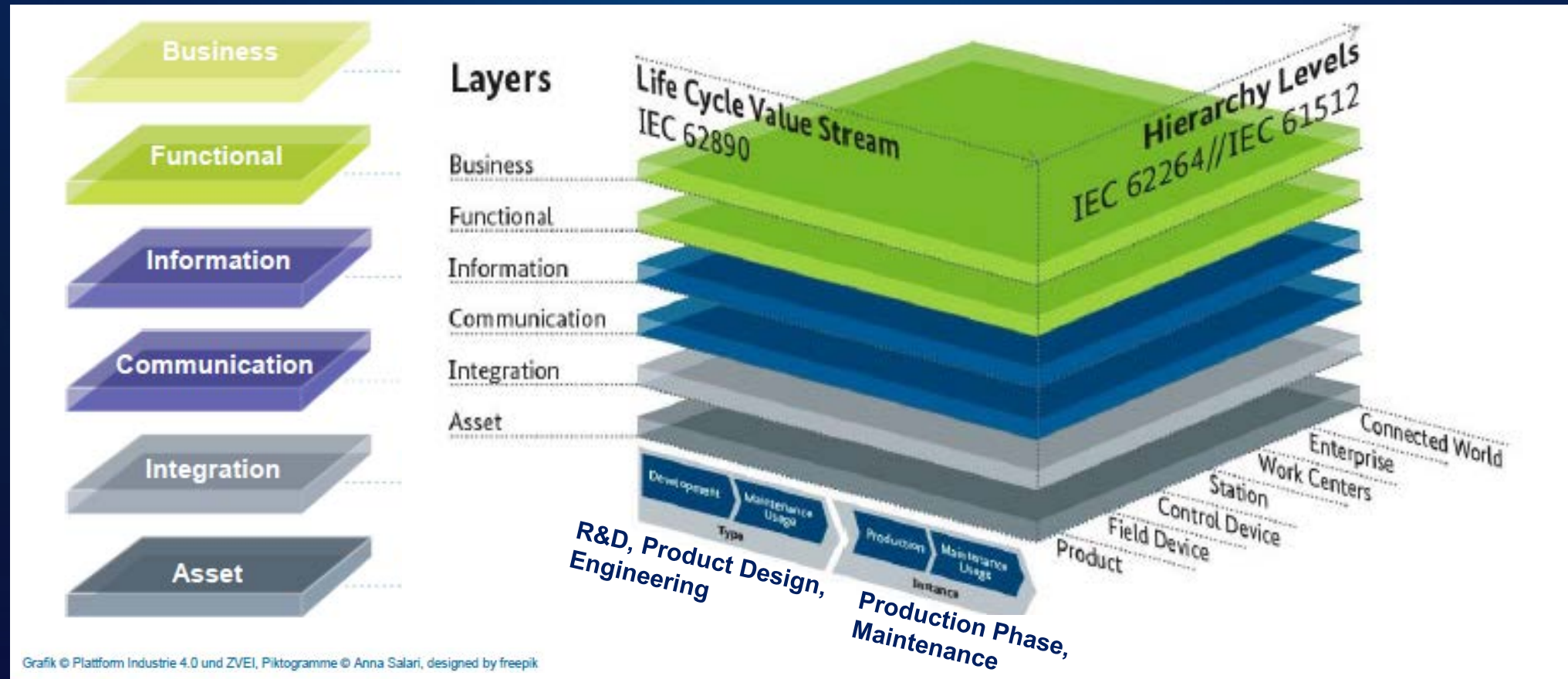
Picture: SmartFactory-KL / A.Sell



5G Impact on RAMI4.0 — Selected Use Cases

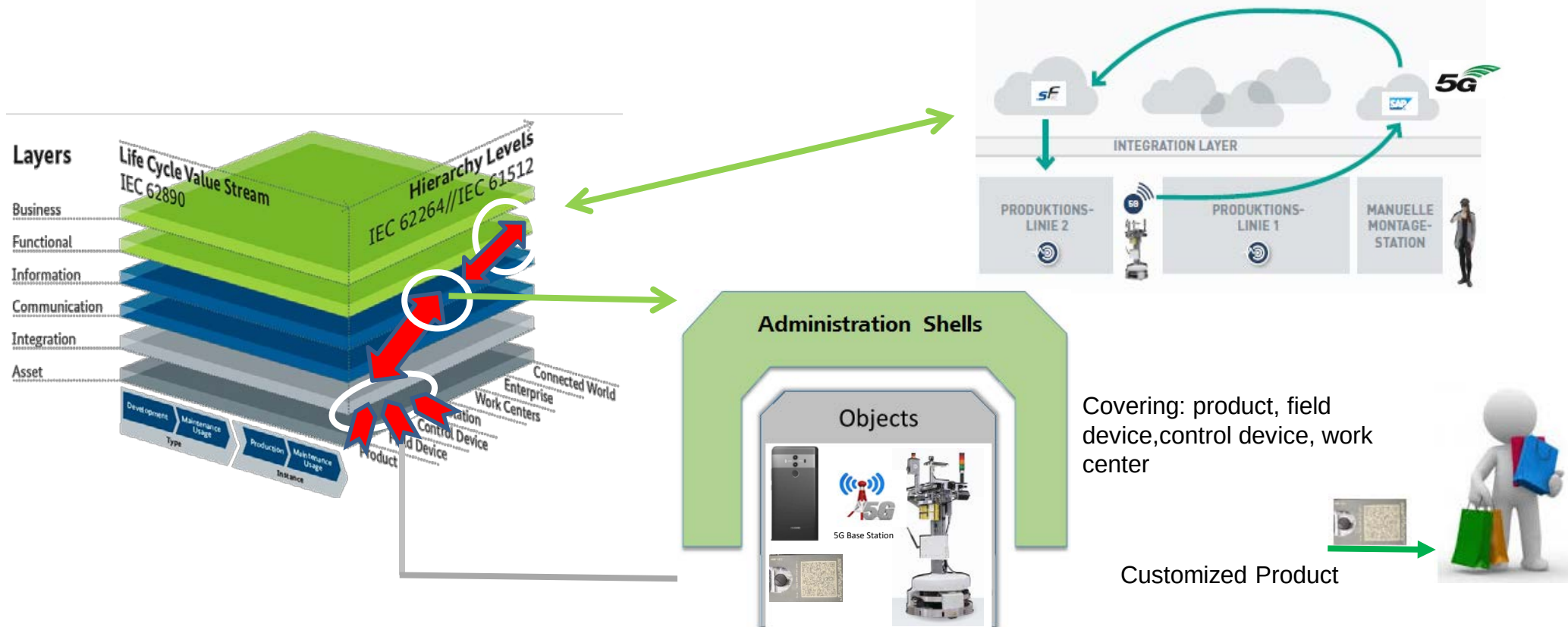


5G Impact on RAMI4.0 — Selected Use Cases



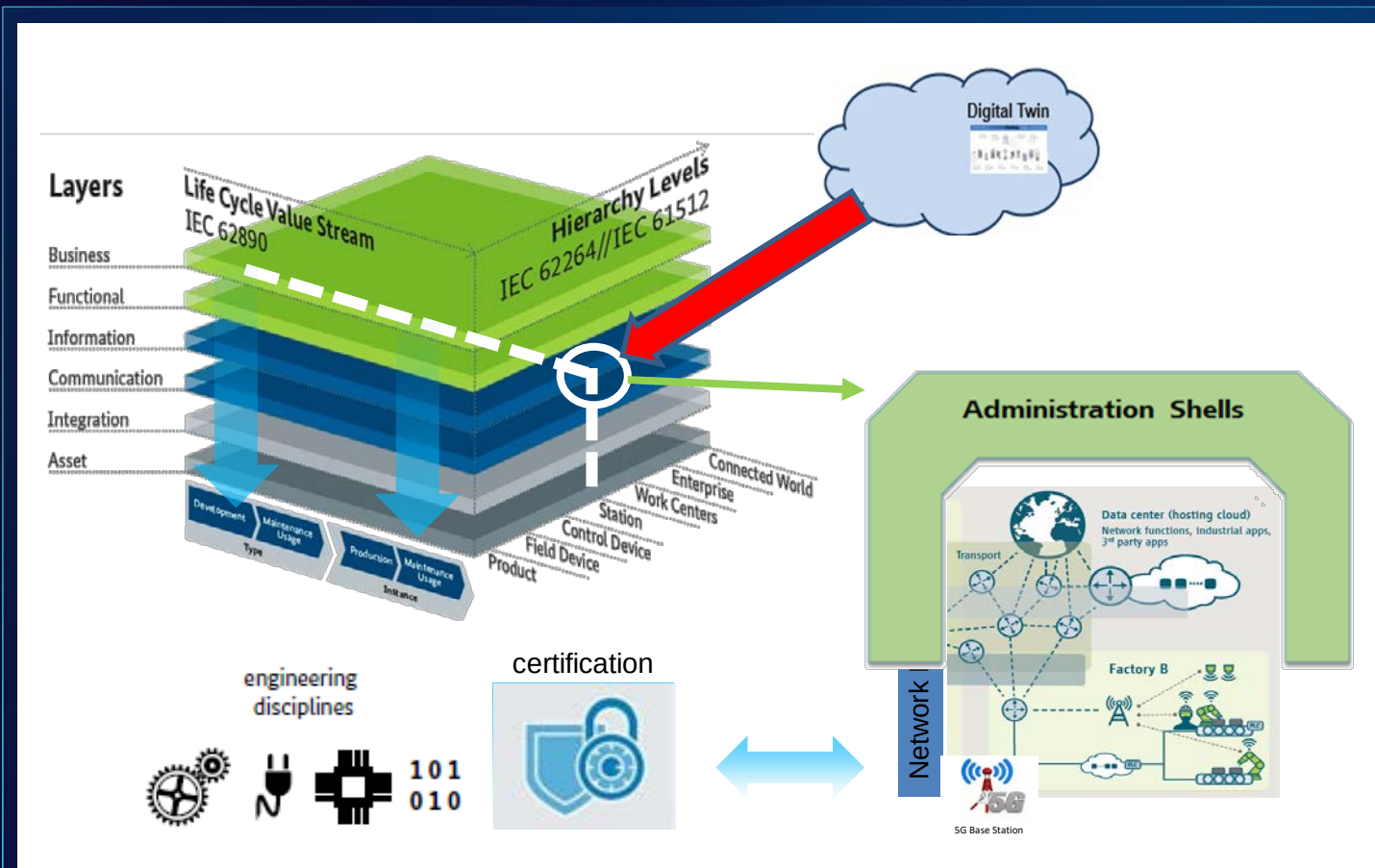
5G Impact on RAMI4.0 — Selected Use Cases 1-3

5G Capabilities and Services: Sensor Data Fusion, Cloud Services for Analytics



5G Impact on RAMI4.0-Need: Alignment of 3GPP –RAMI4.0

5G Capabilities and Services: Demand Dynamic Engineering and Certification



Proposal: Network management to be integrated part of model based systems engineering (MBSA)

Management Services could amend Asset Administration Shells (AAS), if
5G Network becomes asset

Benefits

- Forecasting Capabilities on NW Loads from previous application experience
- Dynamic certification by Use of Risk Models from Digital twin



WG2

5G Enabled Smart Services for Mobile Robots



5G Capabilities & Services: 4 Use Cases

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5G Impact on 4.0 Reference Architecture Model

Related Activities & Discussion



Related Activities & Discussion



www.5G-ACIA.org

5G-ACIA

5G Alliance for Connected Industries and Automation

A Working Party of ZVEI-German Electrical and Electronic Manufacturers Association

PLATFORM PUBLICATION - The Working paper of the Working group 2 -on research and innovation- describes the potentials and new tasks that arise when (mobile) production resources are controlled, analyzed and optimized using 5G technology and cloud services.

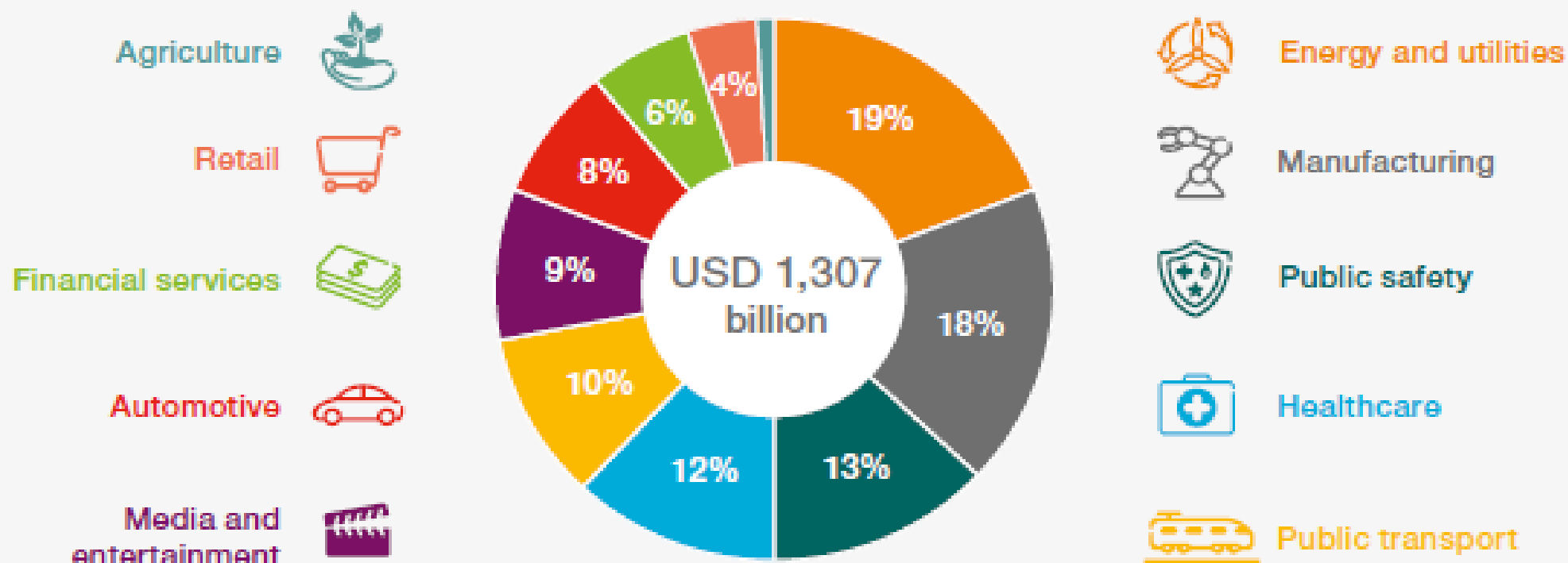
<https://www.plattform-i40.de/I40/Navigation/EN/InPractice/Online-Library/online-library.html>

5G enabled Revenues for Manufacturing

Digital revenue for ICT players: ~ USD 3.5 trillion by 2026 across the 10 key industries studied

5G Enabled Revenue: USD 1.307 billion

Manufacturing: 18%



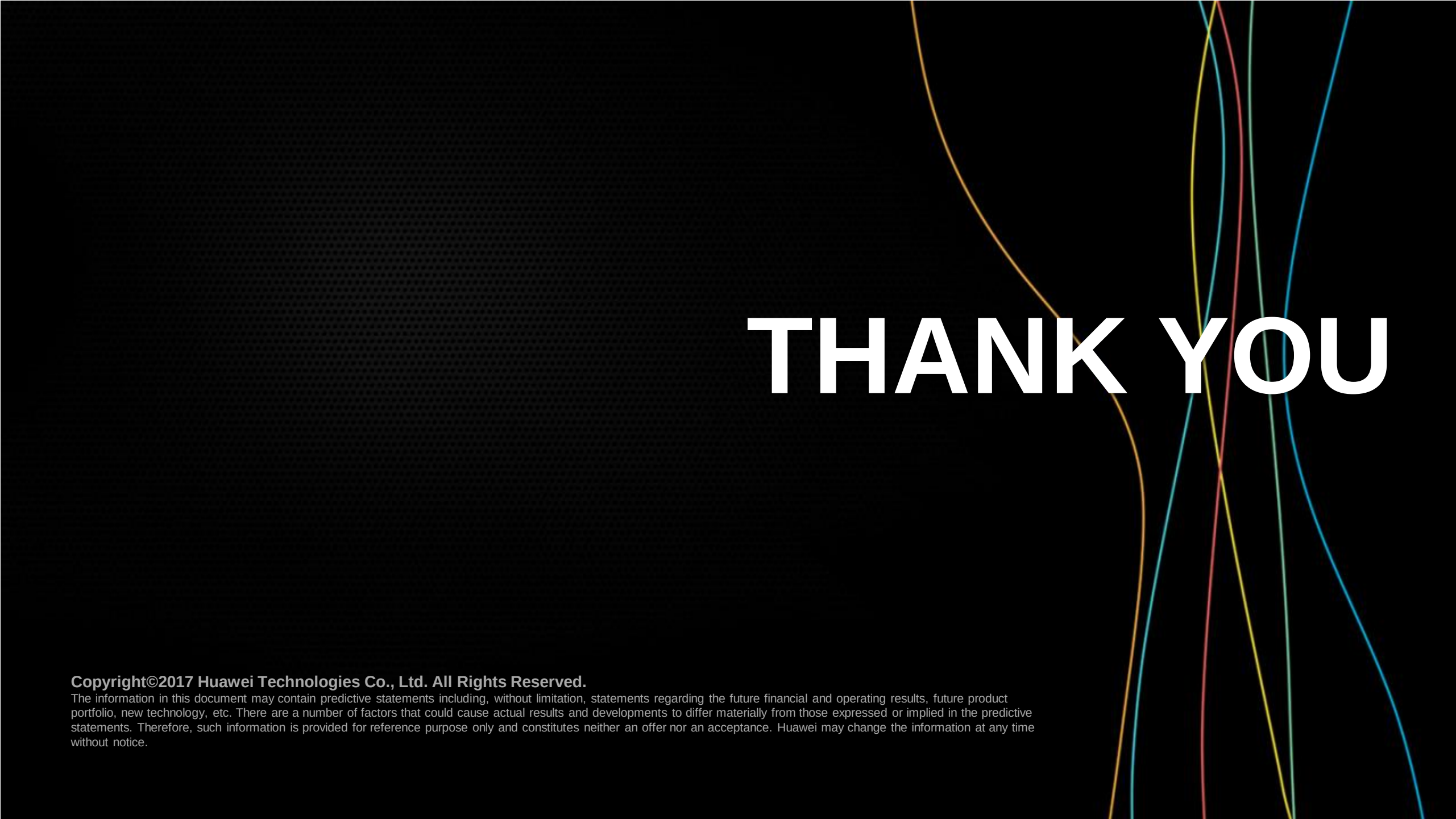
Source: Ericsson and Arthur D. Little

Huawei a global leader in ICT solutions



Huawei at a glance – Overview

Global positioning						
	180,000 Employees	80,000 R&D employees	170+ Countries	15 R&D institute and centers	No. 72 Interbrand's Top 100 Best Global Brands	No. 83 Fortune Global 500
Business units	Consumer Business A brand loved by consumers		Carrier Business Customers' best strategic partner		Enterprise Business Enabler and preferred partner of enterprise digital transformation	
	 Serving hundreds of millions of consumers		 Serving global carriers		 Serving global enterprises industry customers	
Products and solutions	Smartphones & Wearables MBB & home devices M2M devices Vehicle telematics		Wireless networks Fixed networks Carrier software and core networks	Enterprise networks IoT connection management platforms	Data Center infrastructure Big data analytics platforms Cloud Services	

The background is black with several thin, curved lines in orange, yellow, red, and light blue that sweep across the right side of the image.

THANK YOU

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