State of Play of Industrial 5G

Dr. Andreas Mueller | Robert Bosch GmbH

State of Play of Industrial 5G
Key Building Blocks for the Digital Transformation

(Private) 5G

Edge & Cloud

AI / ML

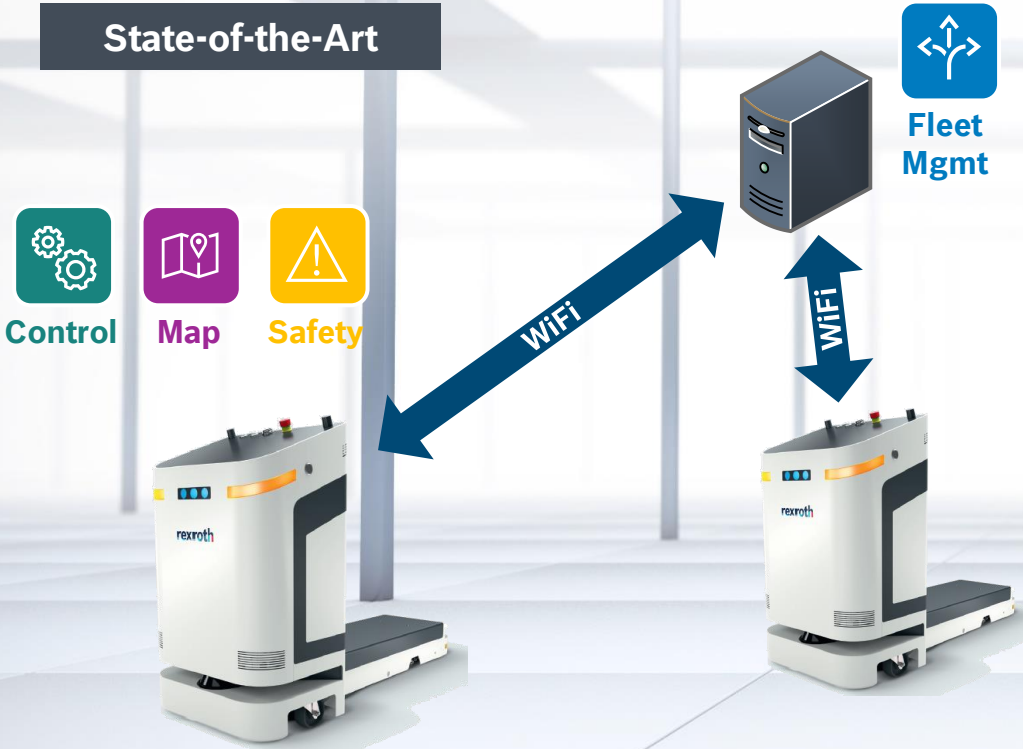**Digital backbone & future-proof innovation platform for many vertical industries**

Marilyn Ferguson

„Transformation is a journey without a final destination.“

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State of Play of Industrial 5G
Exemplary Use Case

AI / ML

Location   Control   Map   Fleet Mgmt

State-of-the-Art

Fleet Mgmt

Control   Map   Safety

WiFi

WiFi

Future

Safety

Closed-Loop Control

5G

Edge Cloud

5G

5G Sidelink

➡ **5G as an enabler for more lightweight devices, easy upgradability, enhanced functionality & higher productivity**

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5G USE CASES

FACTORY OF THE FUTURE

For unprecedented levels of flexibility, productivity, efficiency and ease-of-use.

Visual inspection

Augmented & virtual reality

Modular production

Intralogistics & mobile robots

Convergence of communication systems

Smart tools

Asset tracking

Retrofitting

Moving & rotating parts

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Why Private Networks?

Images: Bosch
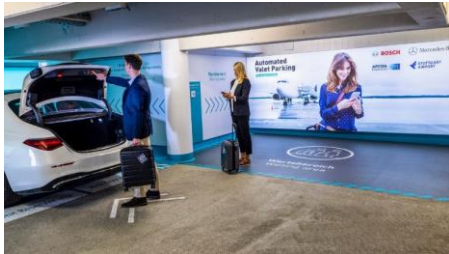
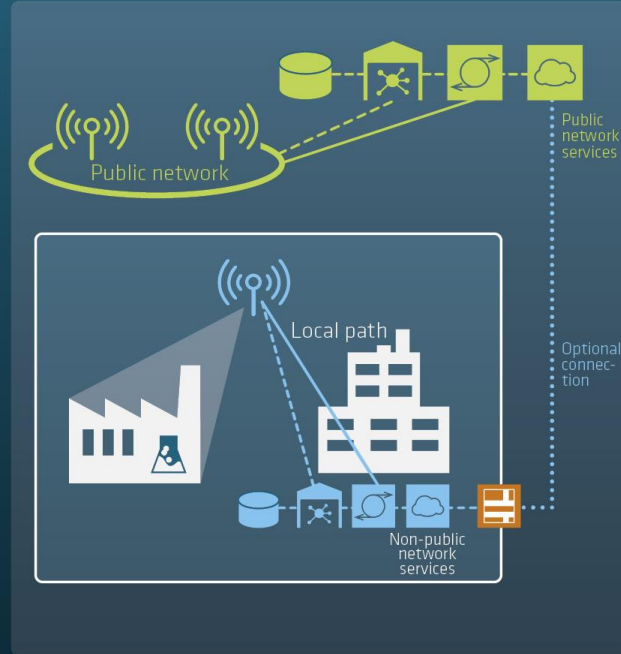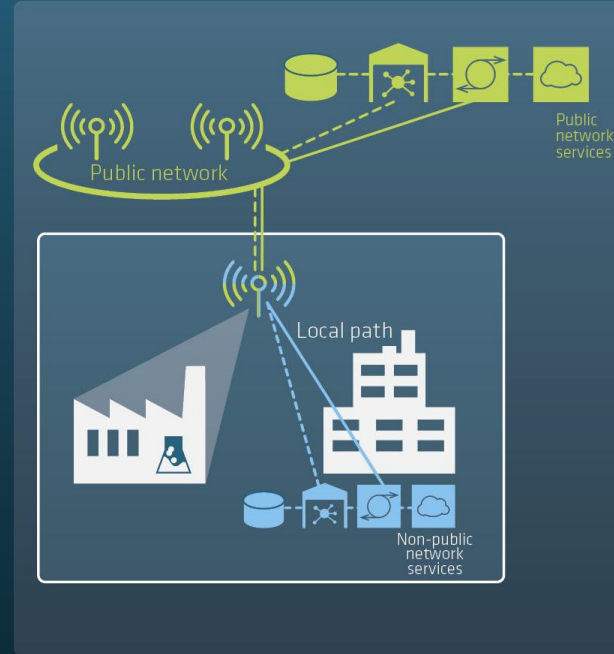**Most vertical applications require only _local_ connectivity, but with special constraints & requirements**

„How can I avoid a vendor lock-in?"

„Can I optimize the network infrastructure according to _my_ needs?"

„Can I act and change things whenever I want?"

„How can I keep full control of my data and minimize security risks?"

„What if something goes wrong? Who takes liability?"

Vertical User Concerns

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Diverse Deployment Models for Private 5G Networks
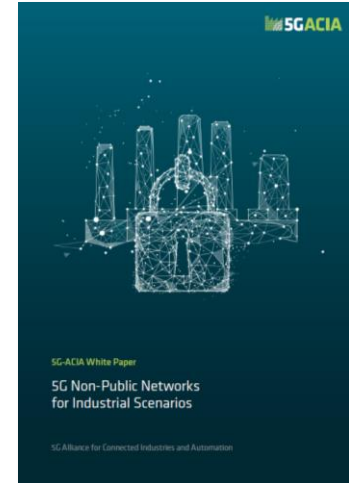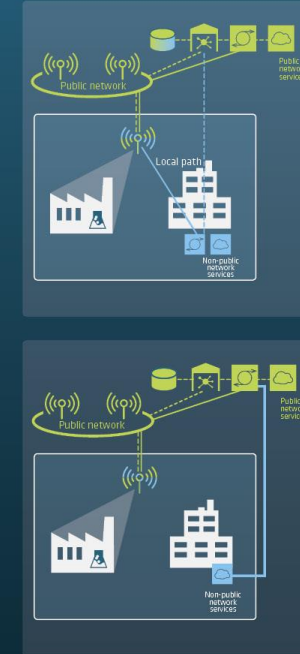
Source: 5G-ACIA

The world is not black-and-white → many options for deploying private 5G networks exist!

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Global Regulatory Situation (non-exhaustive, w/o any guarantee ☺)

Legend:
- **Local spectrum decided** (green)
- **Local spectrum discussed** (orange)
- **Not yet considered / unknown** (grey)

Status Quo in Germany[1]

>230 Granted campus licenses in 3.7 – 3.8 GHz band

14 Granted campus licenses in 26 GHz band

[1]as of Sep 2022

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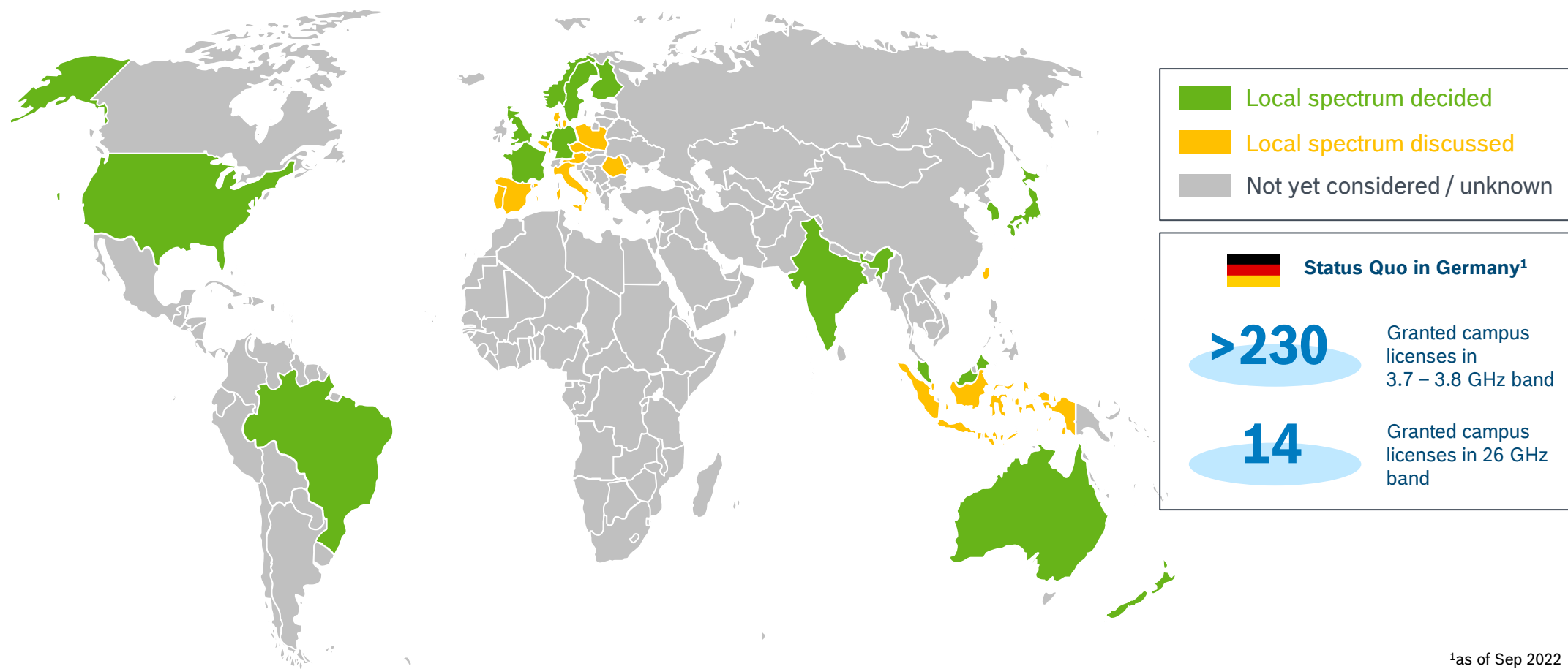
Private 5G: Status Quo

Many relevant features specified (e.g., in 3GPP)

Diverse operating models available (e.g., 5G-ACIA)

Private spectrum licenses increasingly available

More and more dedicated offers for enterprises

Many new market entrants, incl. start-ups

High speed of innovation

Mining & ports among early adopters

Manufacturing yet to catch up

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Bosch 5G Campus Network in Stuttgart, Germany

A central 5G testbed for Bosch:

- Extensive performance evaluation and validation in real-world environment

- Basis for proof-of-concept / prototype development and testing

- Validation of concepts and approaches for secure integration of 5G into existing IT infrastructure

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Bosch 5G Campus Network in Reutlingen, Germany

Testing 5G in a semiconductor factory:

- Extensive channel measurements
- Possible impact on production equipment
- Cloud robotics
- Industrial LAN over 5G

State of Play of Industrial 5G
Selected Remaining Challenges

▶ The availability of a **technology alone is not enough** to make it a market success

▶ An ecosystem of infrastructure **equipment, devices & services** has to grow from scratch

▶ There is a **chicken-egg challenge** for overcoming the initial barrier for market adoption

Current Challenges

Differentiating features for vertical industries come only with **Rel-16** and beyond

Different innovation cycles in ICT industry and vertical industries

Purely **RoI[1]-driven investment decisions** → Initial costs for equipment & services too high

Development of use cases requires **integration with other technologies / building blocks**

Way Forward

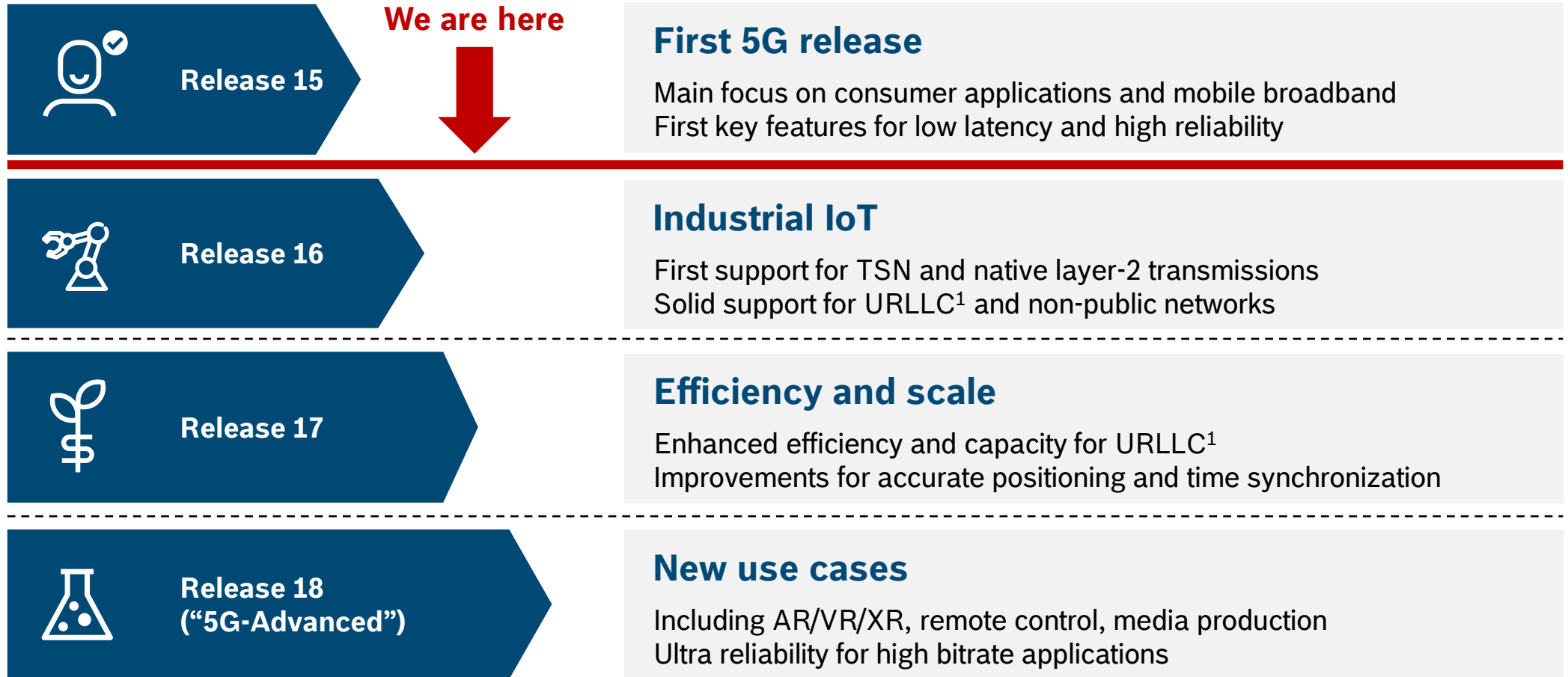**Close collaboration & co-creation**

Profiling & certification

Synergies across verticals

Win through convergence

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State of Play of Industrial 5G
Evolution of 5G Standards

We are here

Release 15

First 5G release

Main focus on consumer applications and mobile broadband
First key features for low latency and high reliability

Release 16

Industrial IoT

First support for TSN and native layer-2 transmissions
Solid support for URLLC[1] and non-public networks

Release 17

Efficiency and scale

Enhanced efficiency and capacity for URLLC[1]
Improvements for accurate positioning and time synchronization

**Release 18
("5G-Advanced")**

New use cases

Including AR/VR/XR, remote control, media production
Ultra reliability for high bitrate applications

[1]Ultra-reliable low-latency communication

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The Role of 5G-ACIA

ICT Industry

Uniting ICT & OT

OT Industry

5G-ACIA bridges the gap between the ICT industry and the OT industry, aligns relevant standards & developments and identifies further needs for action
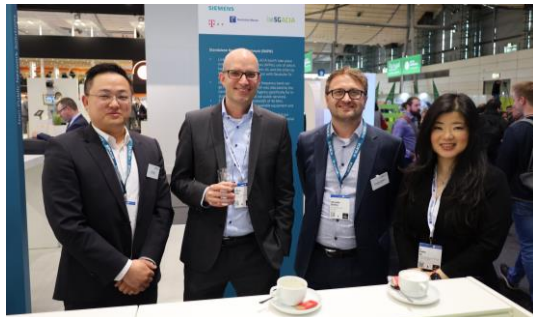
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Current 5G-ACIA Member Overview

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5G-ACIA at Hannover Messe 2022

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5G-ACIA Plenary Meeting in San Diego

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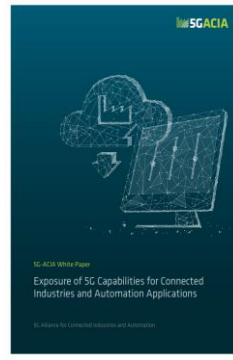
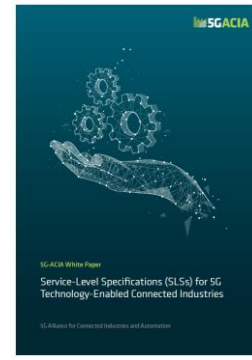# State of Play of Industrial 5G
Recent 5G-ACIA White Papers
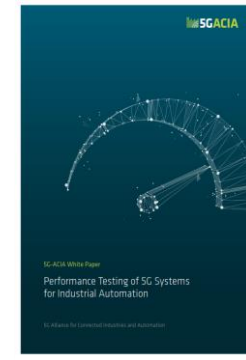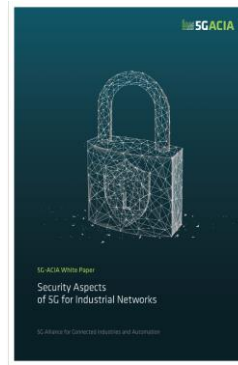

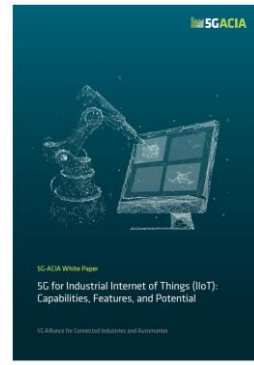**TSN-over-5G**
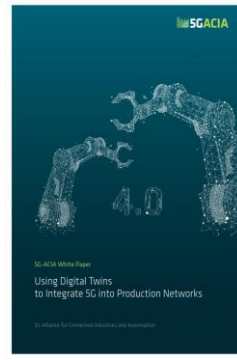
5G Digital Twins

5G Exposure Interface

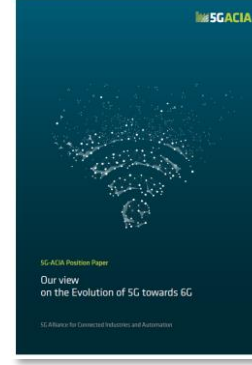**Service-Level Specifications**

Performance Testing

Security

5G IIoT Capabilities

5G QoS

6G Position Paper

5G Industrial Devices
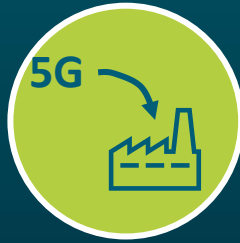
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State of Play of Industrial 5G
5G-ACIA | Selected Topics of Current Interest

Industrial 5G & Edge Computing

Advanced Shopfloor Integration

Advanced Use Cases & Requirements

Market Tracking & Forecasting

Hands-On Guidelines & Best Practices

+ many more exciting and important topics ☺

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Open RAN & Private 5G
- A Perfect Match?

State of Play of Industrial 5G
Driving Forces Behind Open RAN for Vertical Industries

Images: Bosch

- Very heterogeneous requirements & constraints, even within one vertical domain
- Many use cases / problems represent only niche markets → not attractive for big players
- Use cases & requirements may even change over time (e.g., industry 4.0)
- Often only local connectivity is needed, but with very demanding requirements
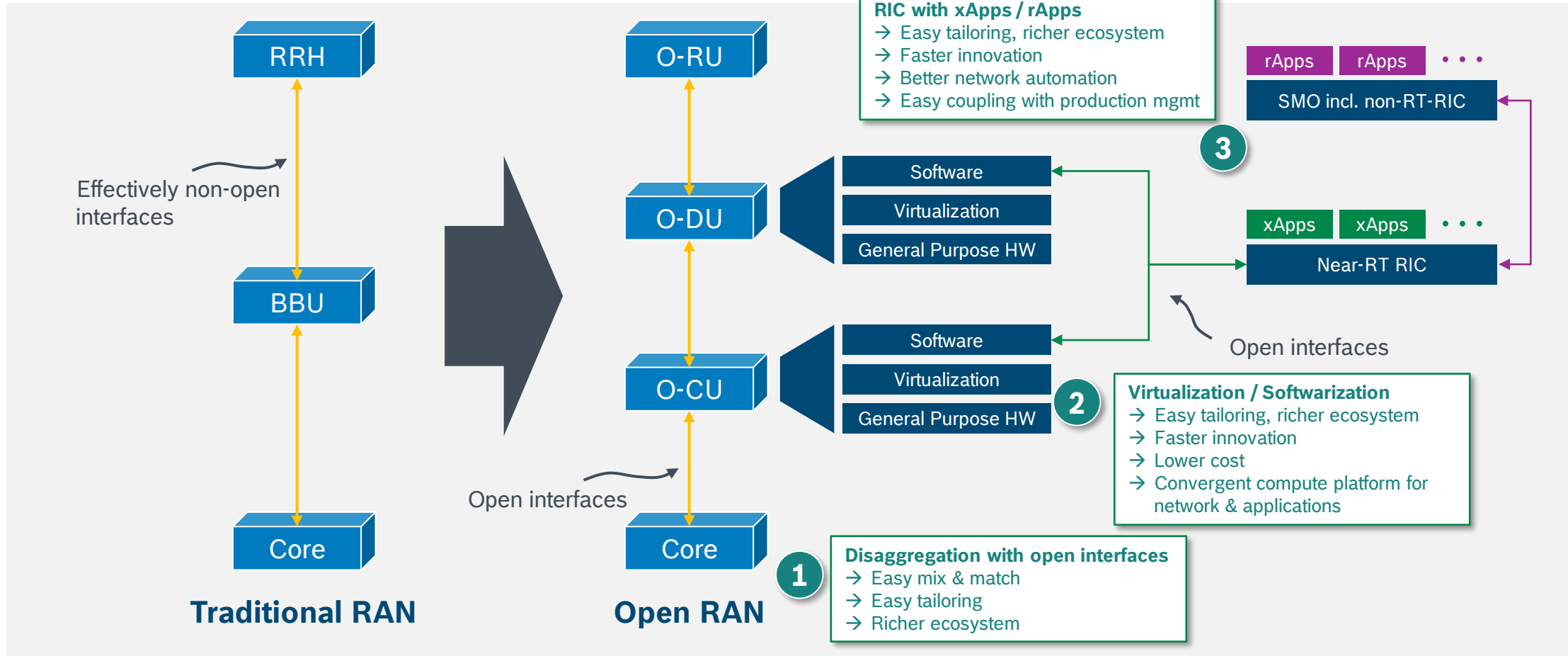- Purely RoI-driven investment decisions → very cost-sensitive
- General trend towards virtualization & softwarization, incl. edge computing

There is a need for highly flexible & customizable solutions with a rich ecosystem of vendors

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State of Play of Industrial 5G
The Promises of Open RAN for Vertical Industries / Private NWs

RIC with xApps / rApps
→ Easy tailoring, richer ecosystem
→ Faster innovation
→ Better network automation
→ Easy coupling with production mgmt

Virtualization / Softwarization
→ Easy tailoring, richer ecosystem
→ Faster innovation
→ Lower cost
→ Convergent compute platform for network & applications

Disaggregation with open interfaces
→ Easy mix & match
→ Easy tailoring
→ Richer ecosystem

Effectively non-open interfaces

Open interfaces

Traditional RAN

Open RAN

RRH: Remote Radio Head, BBU: Baseband Unit, RAN: Radio Access Network, RU: Radio Unit, DU: Distributed Unit, CU: Centralized Unit, RIC: RAN Intelligent Controller, SMO: Service Management & Orchestration, RT: Real-Time

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State of Play of Industrial 5G
Private 5G & Open RAN | Selected Challenges

Performance Limitations

Performance sufficient for mission-critical vertical applications?

Support for large bandwidths?

What level of PHY acceleration is needed?

End-to-End Integration

Is an easy mix-and-match a realistic vision?

Who takes care of E2E integration?

Who takes care of liability & support?

Energy Efficiency

Can we significantly improve energy-efficiency in future?

What is the carbon footprint along the entire lifecycle?

Can application-specific tailoring help?

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