Potenziale durch 5G in der Produktionstechnik

Potentials of 5G in production technology

5G Industrie Summit, 2nd September 2020

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Fraunhofer Institute for Production Technology IPT

Agenda

1 Motivation for 5G in Production

2 5G-Industry Campus Europe

3 Selected 5G use cases

4 Conclusion

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Production research from the cutting edge to 5G

- A long time ago

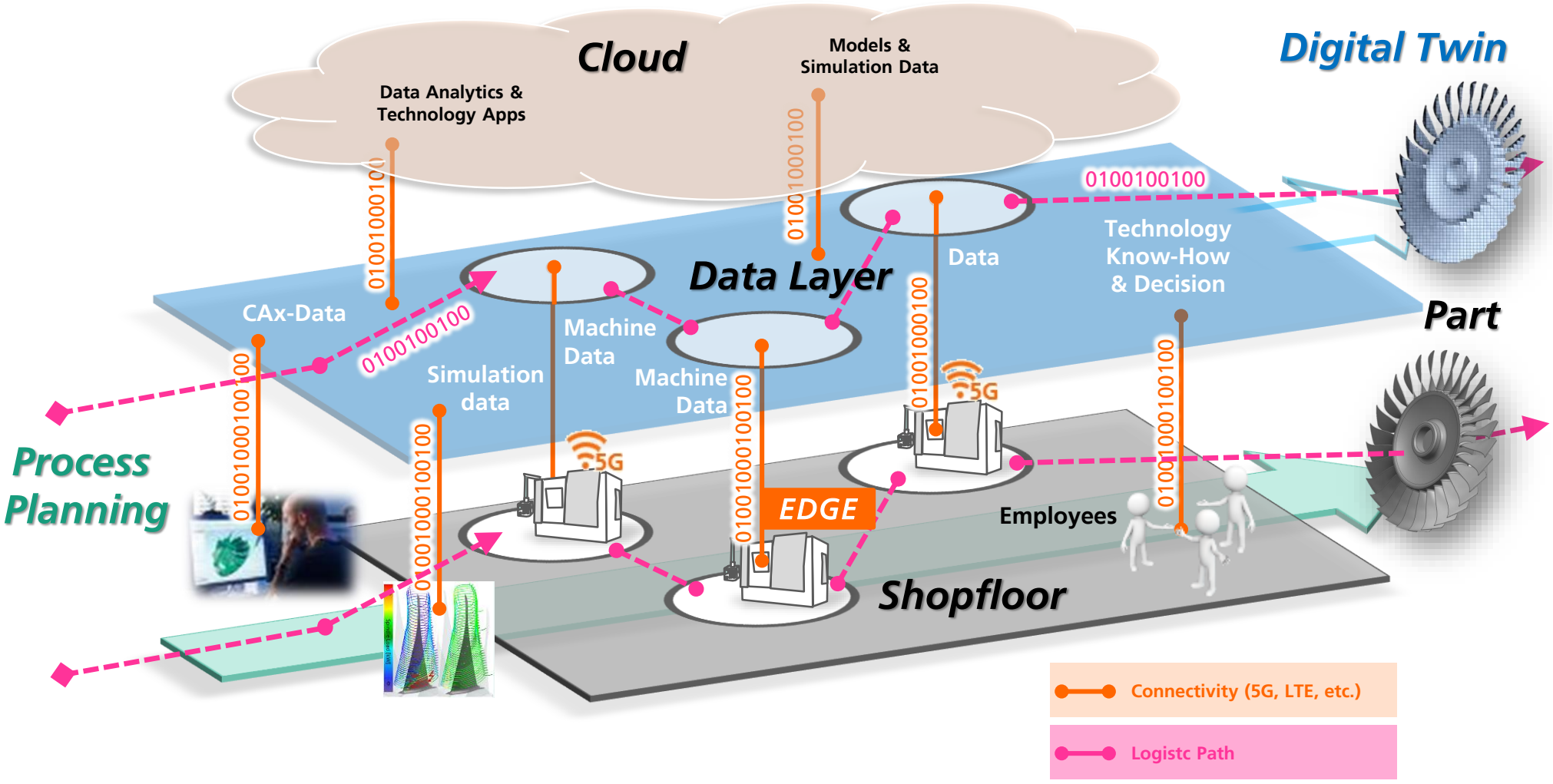
Georg Schlesinger
(1874-1949)

"The dividends sit on the cutting edge of the steel, but the speed of these cutting edges is a function of the machines that move them." (1911)

- Resolving fields of tension: Quality vs. Time vs. Costs
- Integrative production technology resolves the polylemma
  - Production technology can flexibly be used for both mass production and mass customization
  - Integrated, automated planning processes
  - Quality, time, cost are KPI considered at all times
- Strategy: Cognitive, self-optiziming processes
  - Quality by design
  - Process and product monitoring
  - Closed-loop manufacturing
  - Constant process optimization (e.g. using AI)

Source: Cluster of Excellence „Integrative Production Technology for High-Wage Countries" (2006-2017)

Production research from the cutting edge to 5G



Advantages of 5G for production

1 Ultra-reliable low latency communication (URLLC)

- <1 ms end-to-end latency, <20 µs jitter
- 99,999% reliability

2 Enhanced mobile broadband (eMBB)

- < 10 Gbit/s bandwidth

3 Massive machine-type communication (mMTC)

- 100x connected devices (comp. to 4G)
- ~15 years battery life time

4 Localization

- < 1 m position resolution

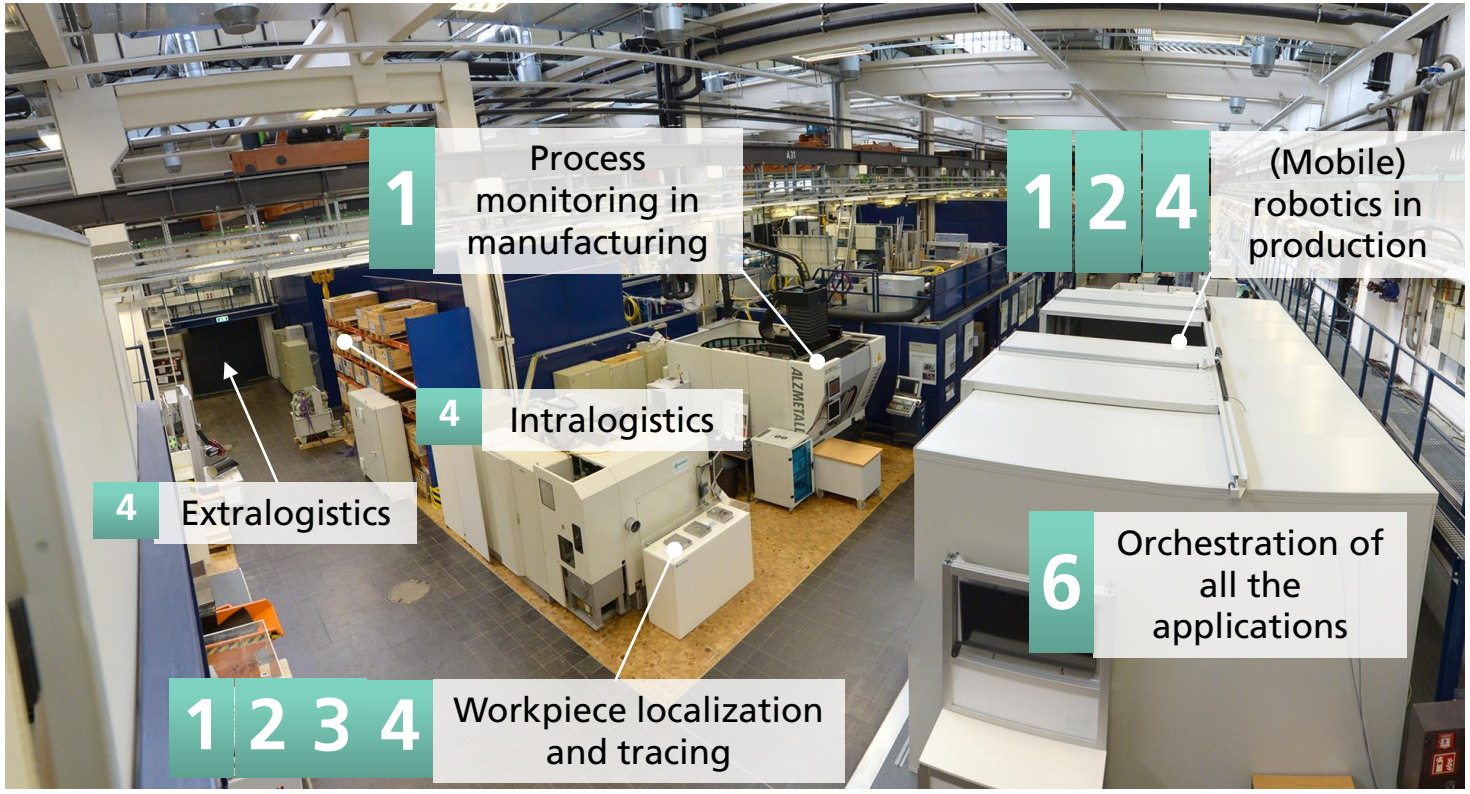
5 Cross-site end-to-end communication

- Site-to-site communication
- Enterprise cloud communication

6 Slicing

- Combine use cases with different criticality levels
- Combine public and private networks

Use case scenarios for 5G in production



1	Ultra-reliable low latency communication (URLLC)
2	Enhanced mobile broadband (eMBB)
3	Massive machine-type communication (mMTC)
4	Localization
5	Cross-site communication
6	Slicing

Requirements 5G-manufacturing ecosystem

1	Universal real-time capable connectivity for existing production equipment – machines, robots, mobile devices, sensors, etc. – replace Bluetooth and WiFi
2	Development of new wireless systems – wireless sensors – 5G-gateways and modules optimized for uplink
3	Enhance IT infrastructure – edge devices, edge-cloud on premise, IIoT middleware / cloud
4	Close the loop in real applications – exploit real-time capability in closed-loop controlled manufacturing – gain credibility with realistic use cases
5	Prove the added value – show that it works! – calculate the financial benefit

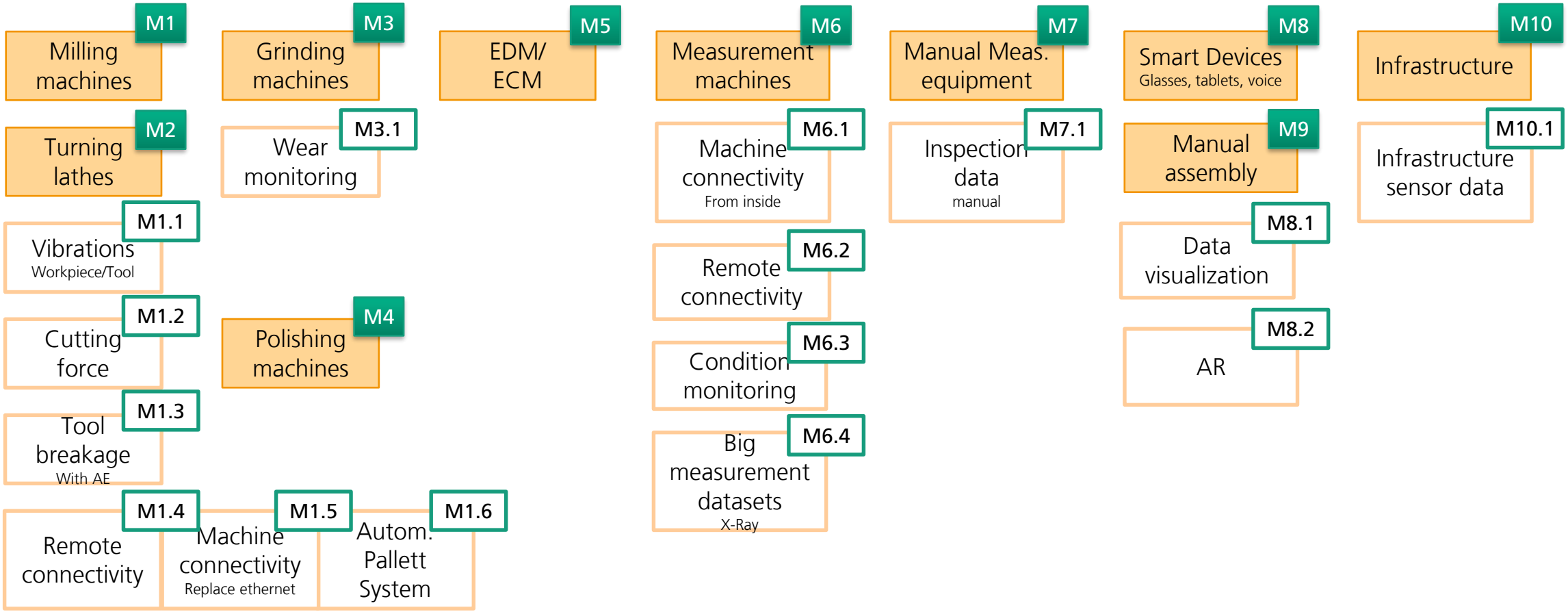
Requirement analysis for 5G connectivity in production

- Results of the study „Development of a reference architecture for 5G-enabled production“ carried out for the International Center for Networked, Adaptive Production“
- Shopfloor layout for a production site with 5G-connectivity

ICNAP www.vernetzte-adaptive-produktion.de

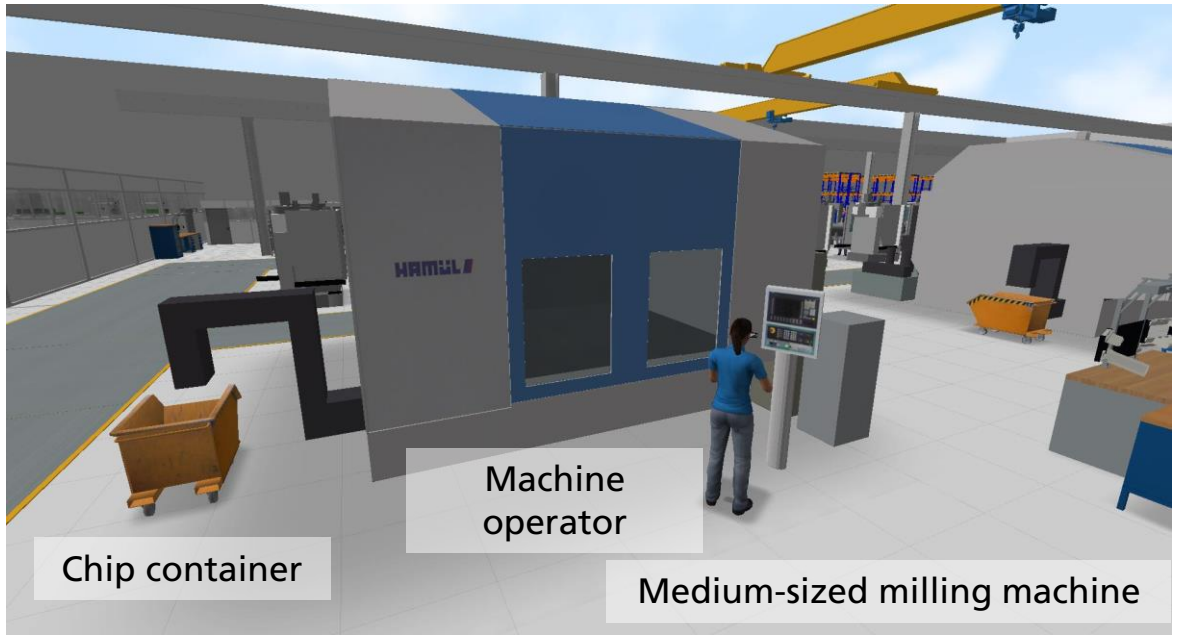
Definition of shopfloor scenario focused on machining

Spectrum of use case mapped to production equipment



Definition of shopfloor scenario focused on machining: M1 (Milling)

M1 Milling machines	46*		
M1.1 Vibrations Workpiece/Tool	46*	< 1 ms	200 byte
M1.2 Cutting force	46*	< 1 ms	30 byte
M1.3 Tool breakage With AE	46*	< 1 ms	40 byte
M1.4 Remote connectivity	46*	< 40 ms	200 kbit
M1.5 Machine connectivity Replace ethernet	46*	depends	depends

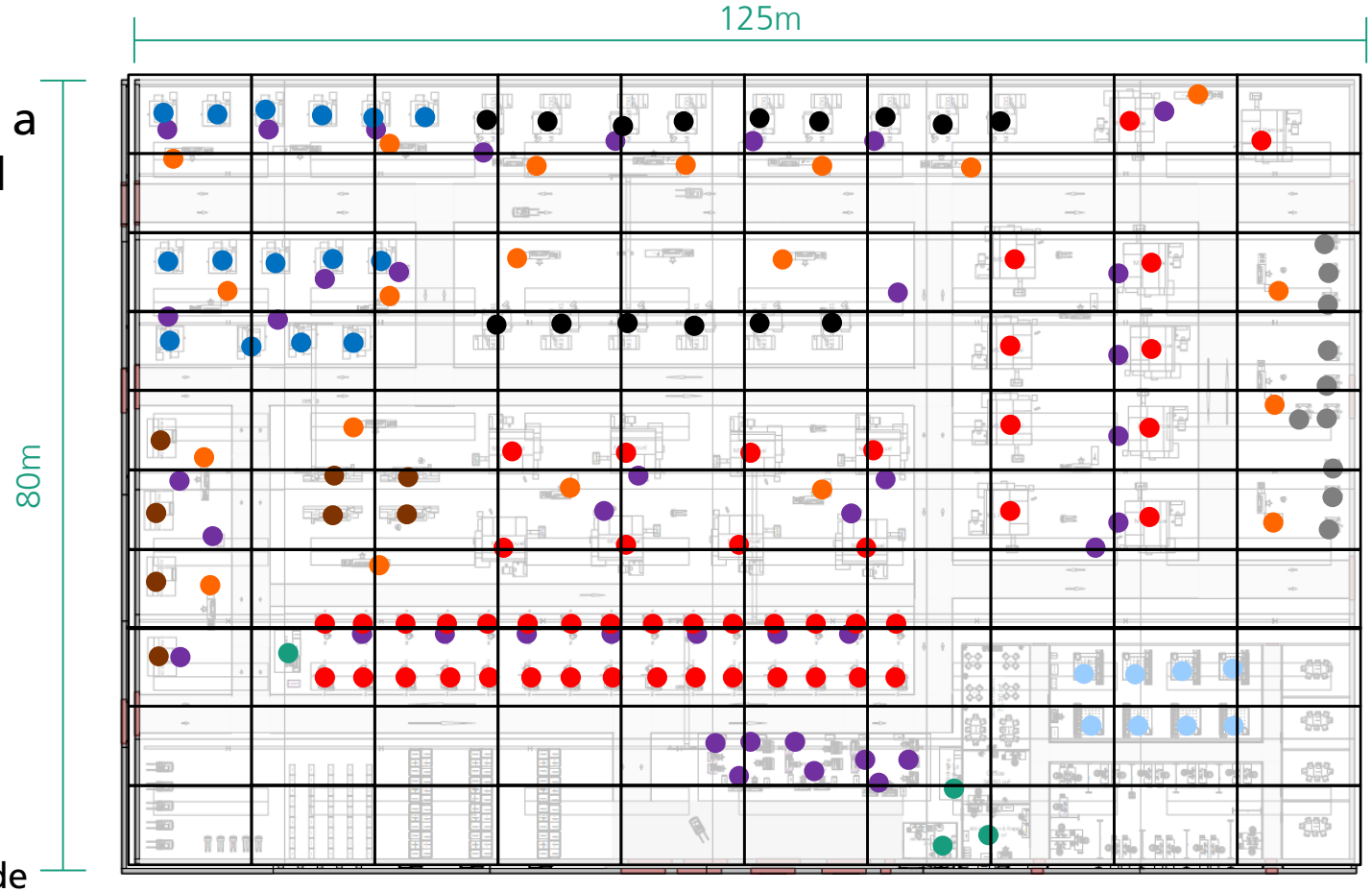


- *= 30 small (1m x 2m), 16 medium (7m x 7m)
- > 99,9999% availability for M1.1 – M1.3
  > 90% für M1.4
  > 99,9999% for M1.5
- Permanent/regular 5G-based monitoring
- Automated pallet systems (temperature, state, location)

Requirement analysis for 5G connectivity in production

Results of the study „Development of a reference architecture for 5G-enabled production“ carried out for the International Center for Networked, Adaptive Production“

- Shopfloor layout for a production site with 5G-connectivity
- >200 5G-Devices with latency requirememement < 10 ms



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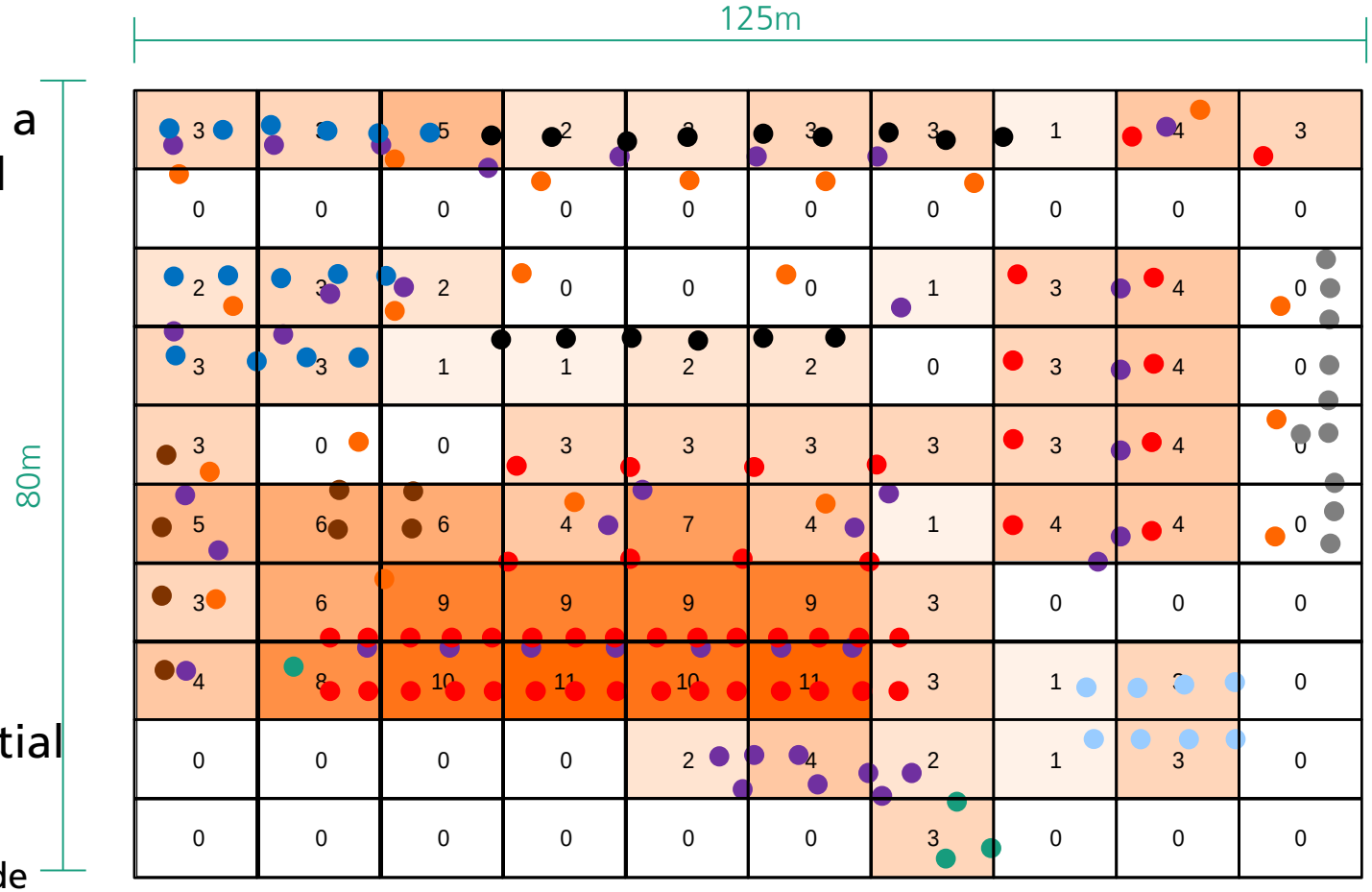
Requirement analysis for 5G connectivity in production

Results of the study „Development of a reference architecture for 5G-enabled production“ carried out for the International Center for Networked, Adaptive Production“

- Shopfloor layout for a production site with 5G-connectivity
- >200 5G-Devices with latency requiremement < 10 ms
- Distribution of devices leads to several heatmaps, which are essential for radio planning



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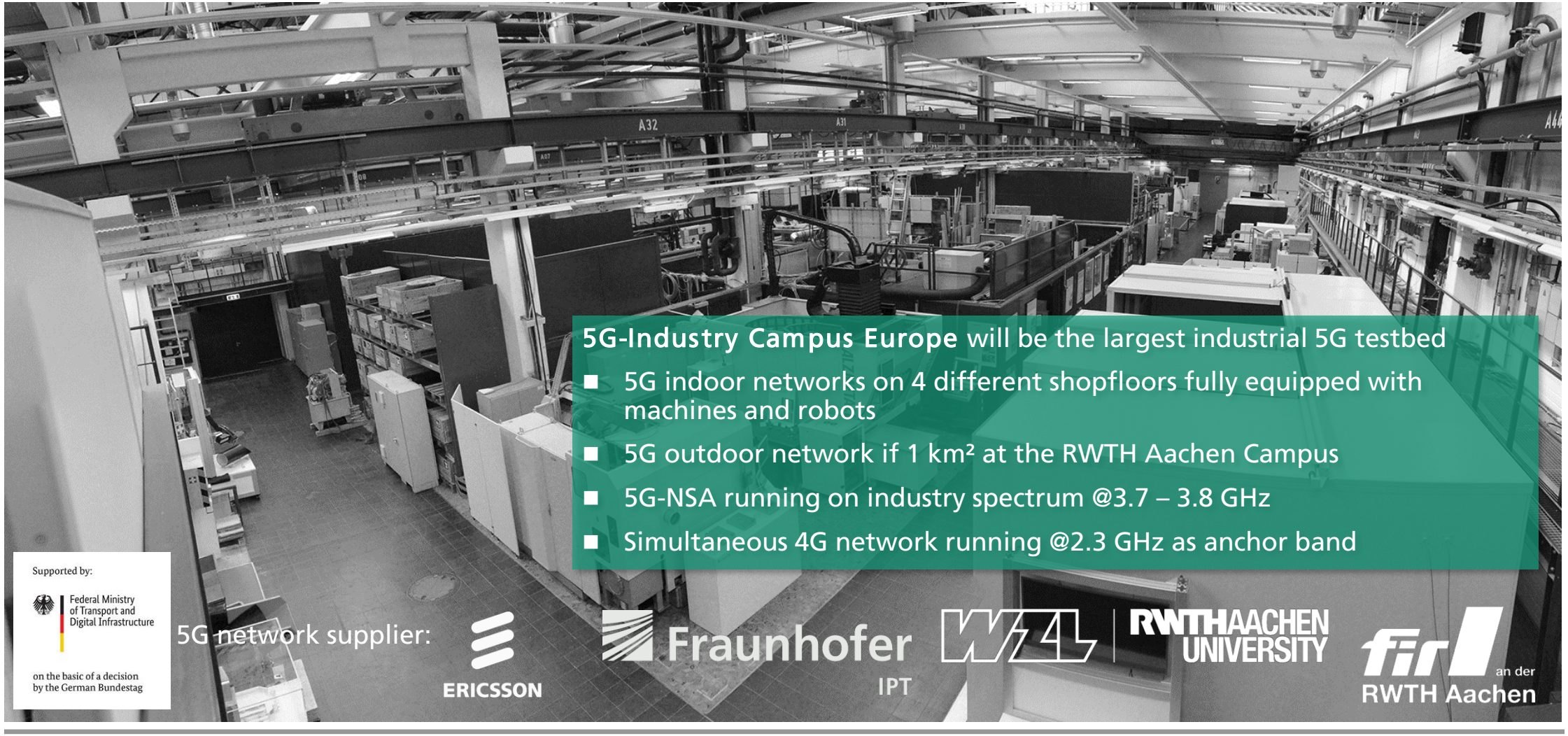
Project for build-up and establishing

5G-Industry Campus Europe



5G-Industry Campus Europe will be the largest industrial 5G testbed

- 5G indoor networks on 4 different shopfloors fully equipped with machines and robots
- 5G outdoor network if 1 km² at the RWTH Aachen Campus
- 5G-NSA running on industry spectrum @3.7 – 3.8 GHz
- Simultaneous 4G network running @2.3 GHz as anchor band

Supported by:
Federal Ministry of Transport and Digital Infrastructure
on the basic of a decision by the German Bundestag

5G network supplier: ERICSSON

Fraunhofer IPT | WZL | RWTH AACHEN UNIVERSITY | fir an der RWTH Aachen

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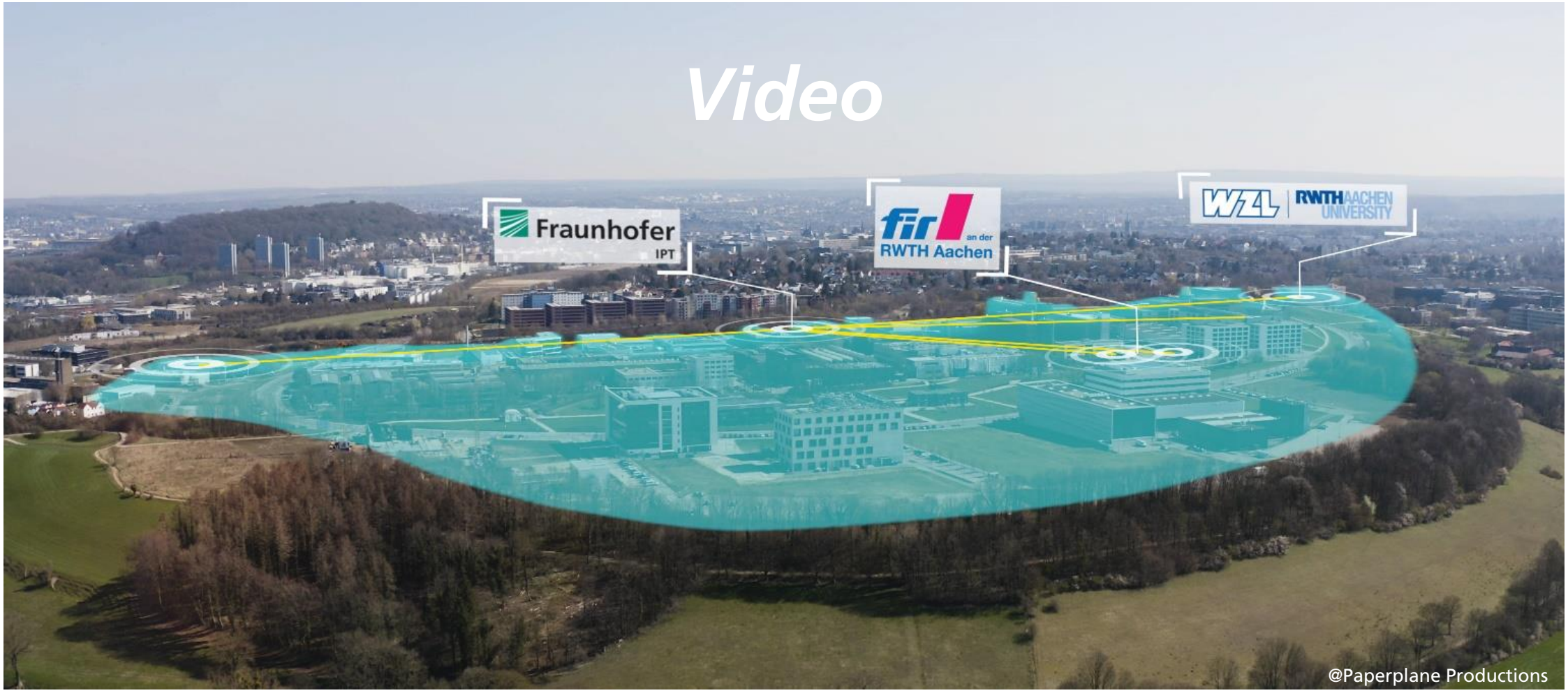
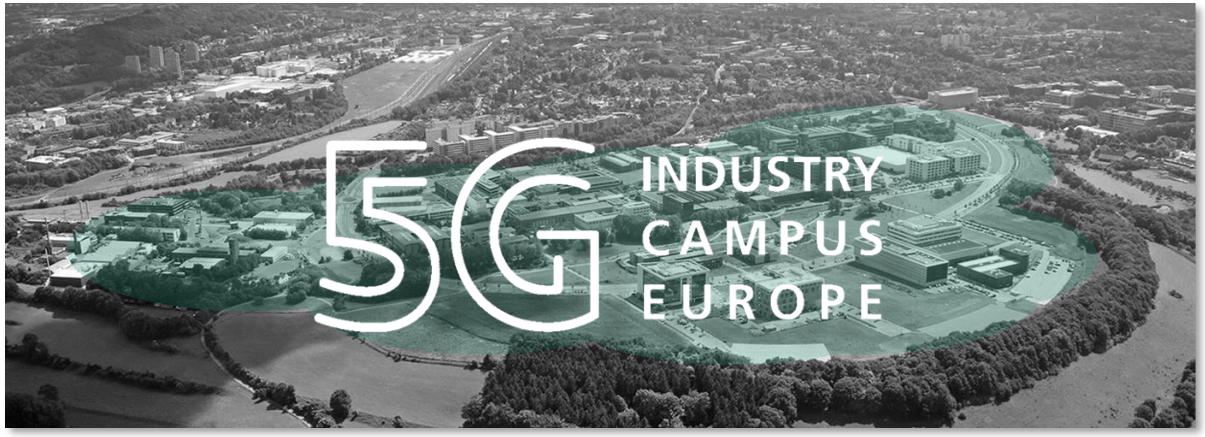
5G-Industry Campus Europe



Watch the video on our website: https://5g-industry-campus.com/

Mission Vision

5G-Industry Campus Europe



5G Industry Campus Europe is

- **The** entity in Europe for the holistic application of 5G to manufacturing and logistics
- **Pioneer** for establishing 5G in industry
- **Application-oriented** with real world use Cases
- **Single-site** as well as **cross-site** perspective

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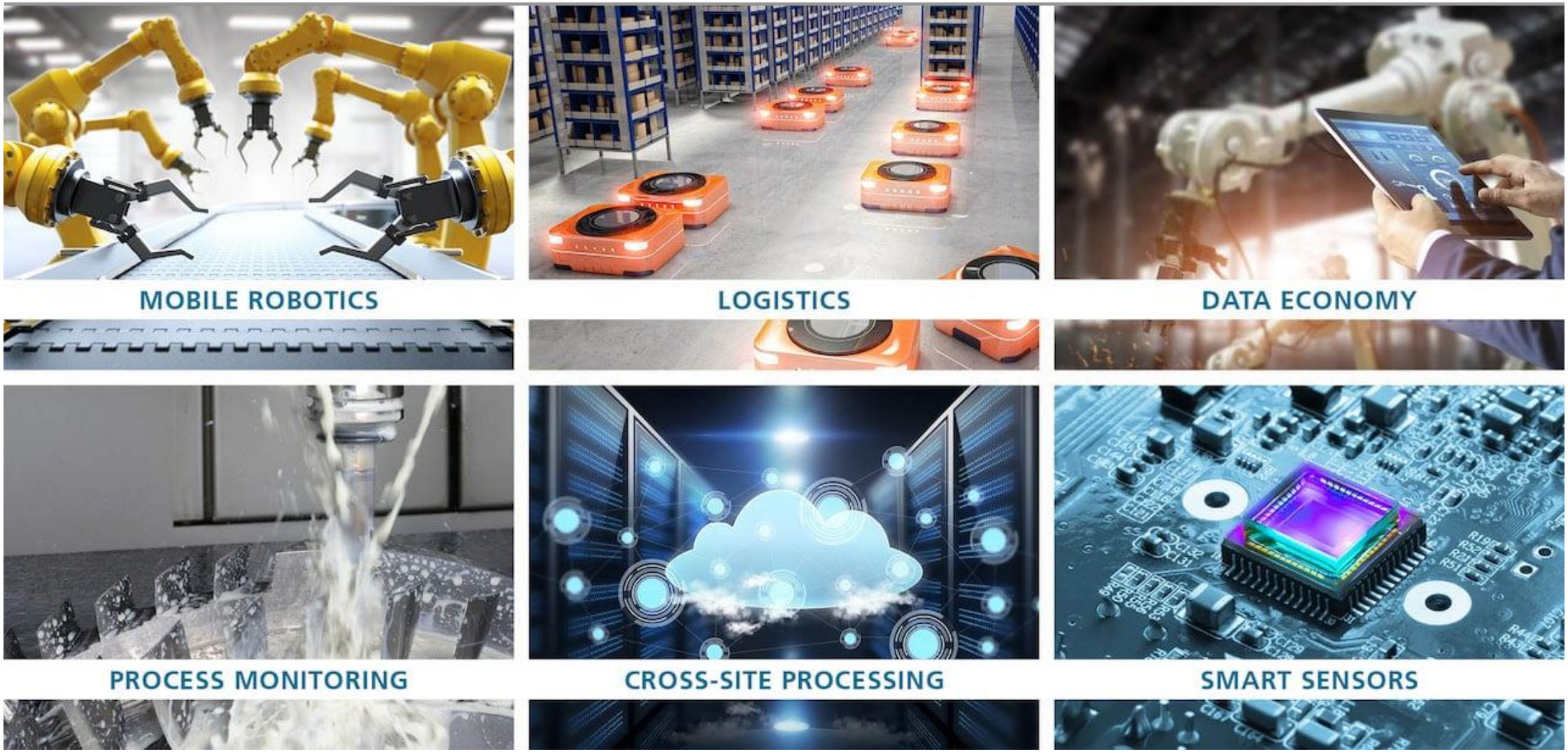
Implementation projects 5G-Industry Campus Europe



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Implementation projects 5G-Industry Campus Europe

5G-AE Sensor

- development of wireless acoustic emission (AE) sensor
- detection of tool breakage and wear

5G-Logistics

- AGV navigation
- transition from indoor to outdoor network
- remote navigation

5G-Multisensor

- multi-sensor platform
- workpiece monitoring and localization
- machine condition monitoring

5G-Blockchain

- data economy for multiple data streams
- connected to blockchain operations

5G-Robotics

- mobile robotics
- sensor guided operation with centralized data processing

5G-Cockpit

- production cockpit with 5G remote machine and sensor connectivity
- digital twin visualization

5G-3D

- wireless optical 3D laser scanner
- seamless machine and robot integration and synchronization

5G-Edge-Cloud

- integration of on-premise edge-cloud
- low-latency data analytics for closed-loop operations

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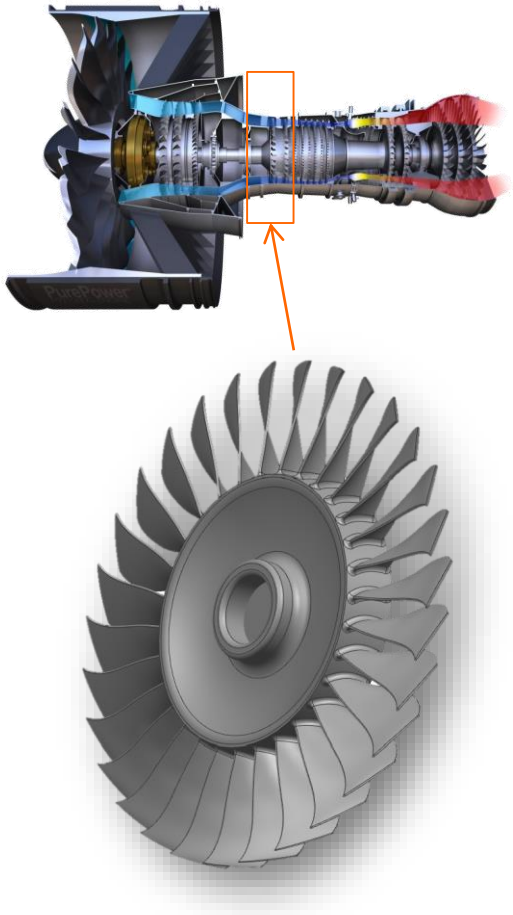
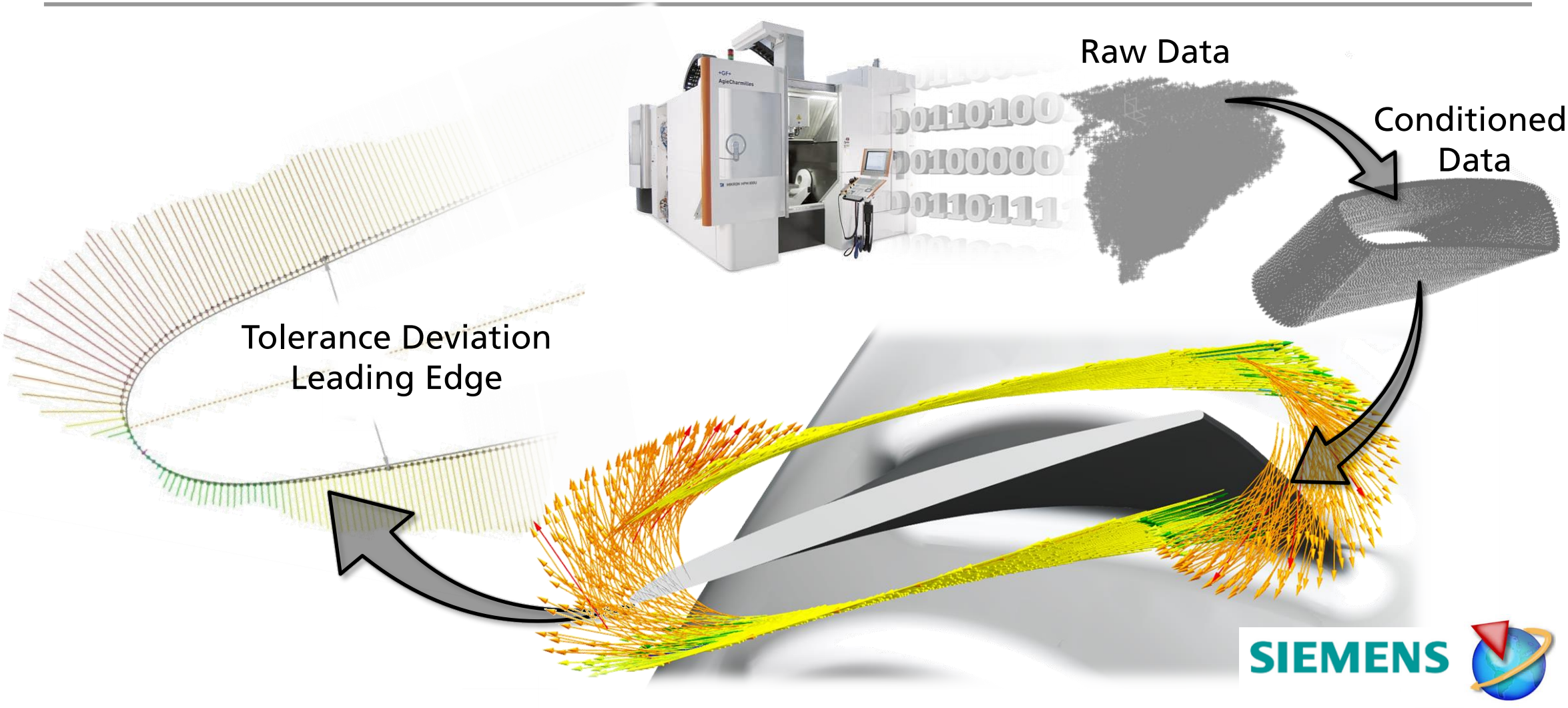
5-axis milling of BLISKs

Pratt & Whitney
PW1100G Engine

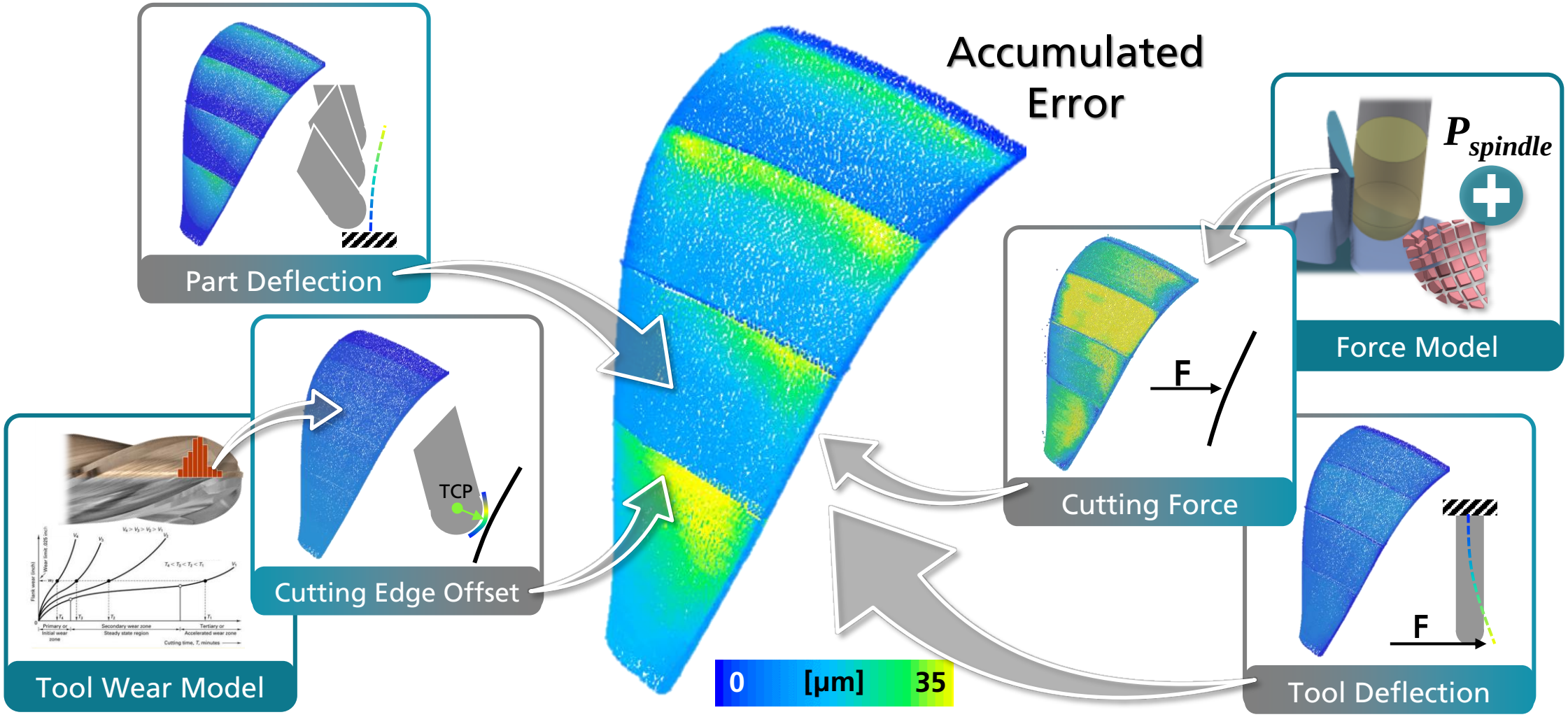


The Most Obvious Use of a Digital Production Environment
Documentation of Quality Relevant Data via “Digital Twins”

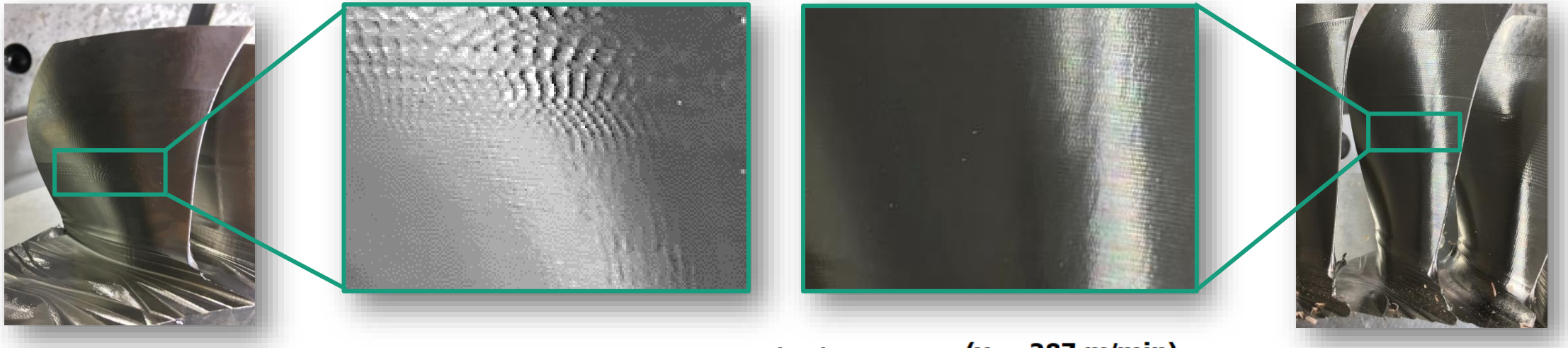


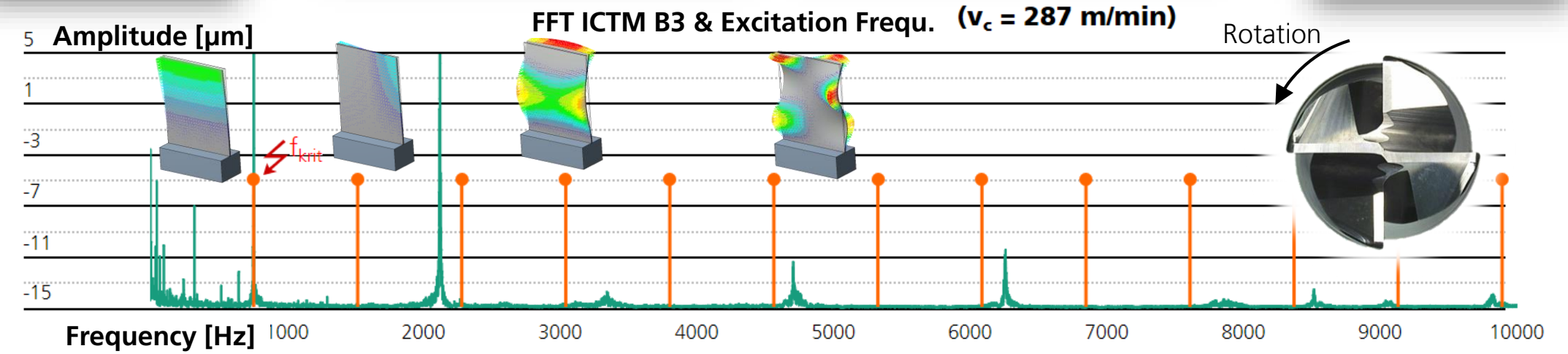
Working with Raw Data from a Manufacturing Environment

Data Conditioning, Filtering, Synchronization and Merging



Stability Indication from FFT





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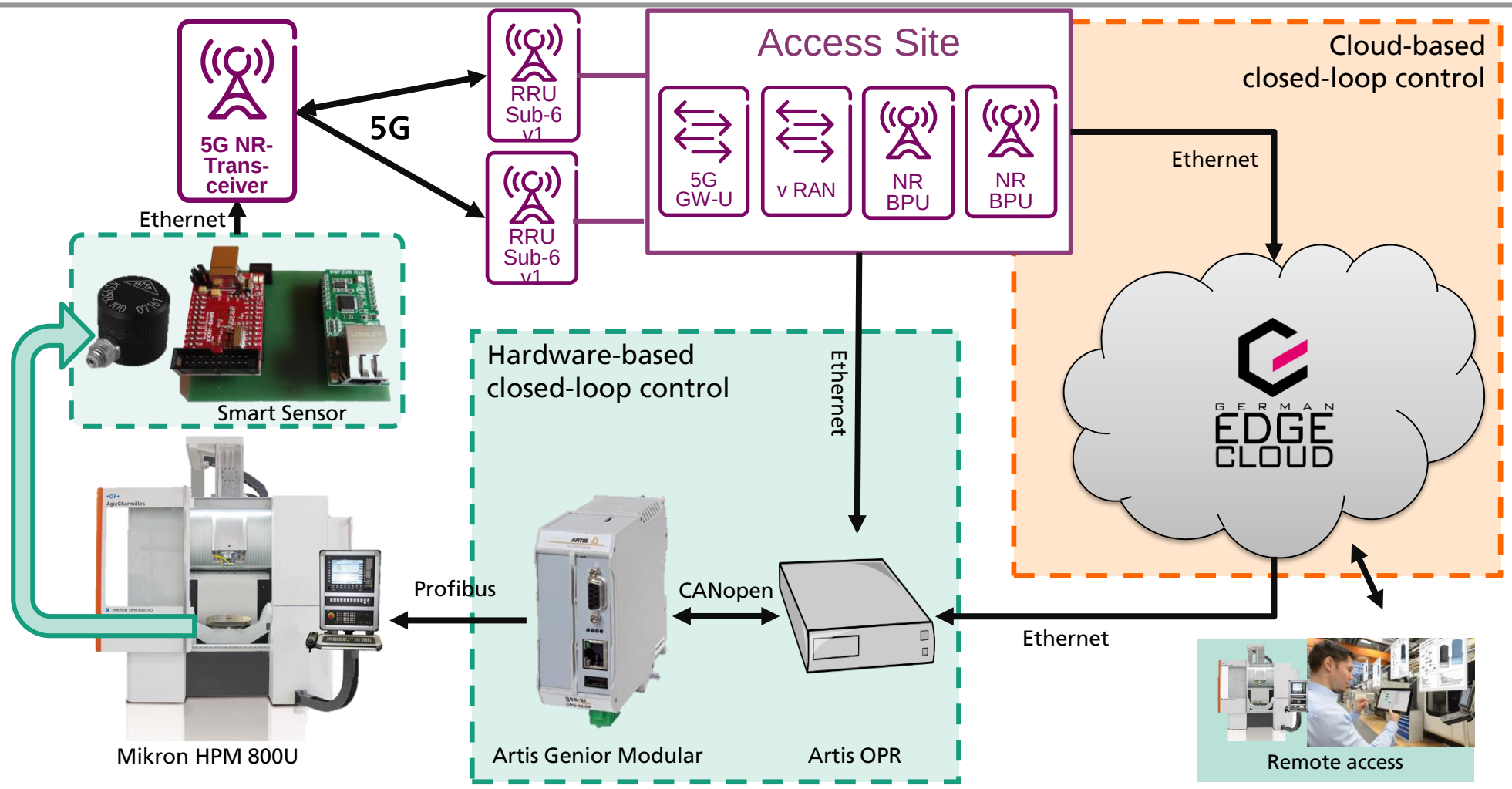
5G System Architecture for Closed-Loop Manufacturing



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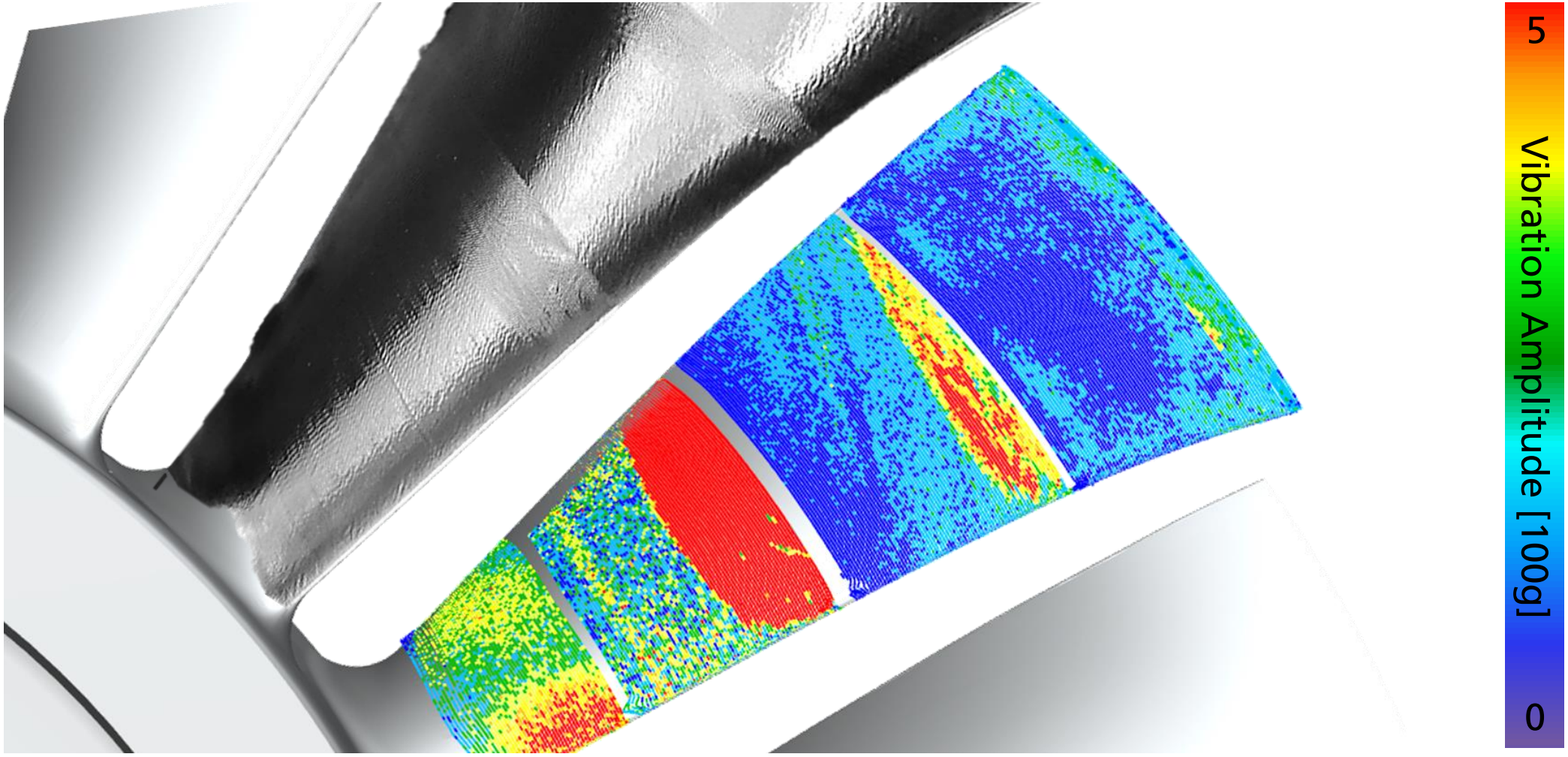
The Fraunhofer IPT & Ericsson Blisk Use-Case

Visualization of Critical Vibrations – *Real* Surface Finish



5G-acoustic emission sensor for in-Process tool wear & breakage detection

5G-AE Sensor

Use Case
- Tool breakage detection in an ongoing milling operation

Motivation
- Adaptive control of complex processes to enhance product quality
- Wireless real-time tracking required

Objectives
- Real-time processing of high-frequency sensor data
- Wireless transmission of processed sensor data
- Algorithmic detection of tool breakage during milling
- Feedback to interrupt the process in case of tool breakage

Technical Challenges
- Large data volumes, latency < 10ms
- Compact design of sensor and data processing hardware
- Detection of the tool breakage signature in the sensor signal

Work Plan
- Requirements analysis of the system functions
- Development of sensor and data processing hardware
- Connection to the cloud system and machine control
- Modelling of empirical experimental data for fracture detection
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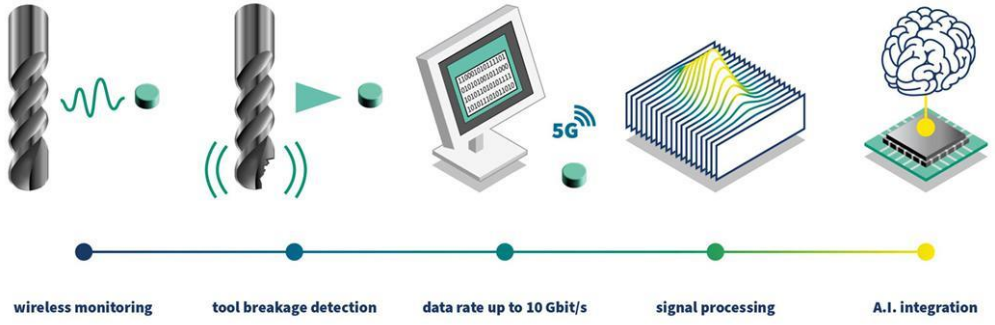

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News and Technical Developments – Projects

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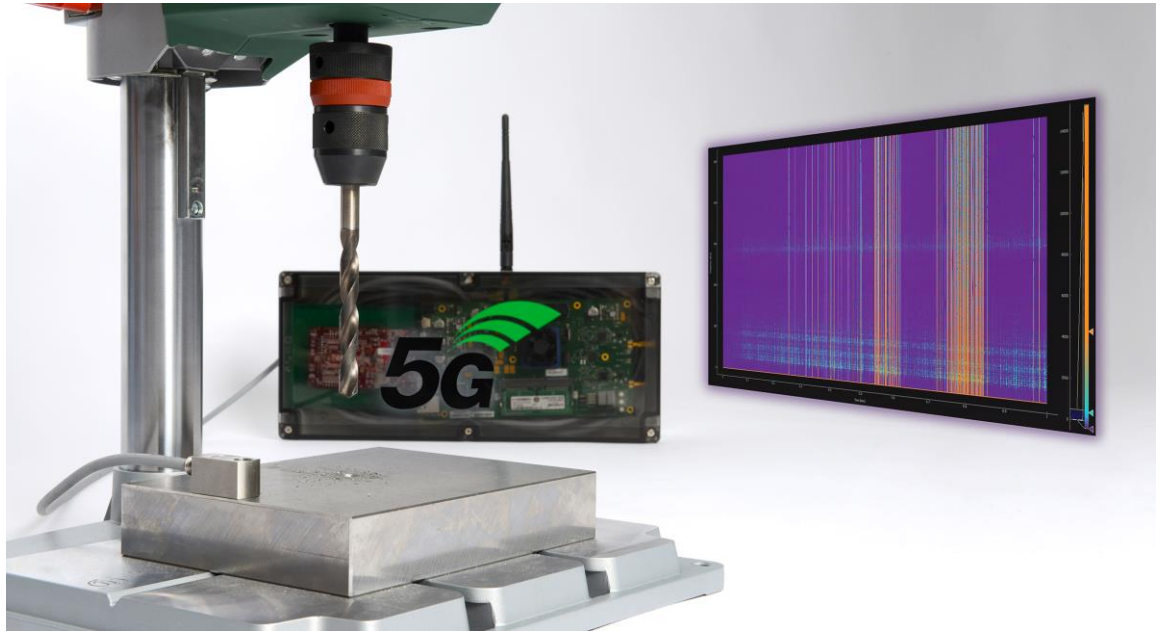

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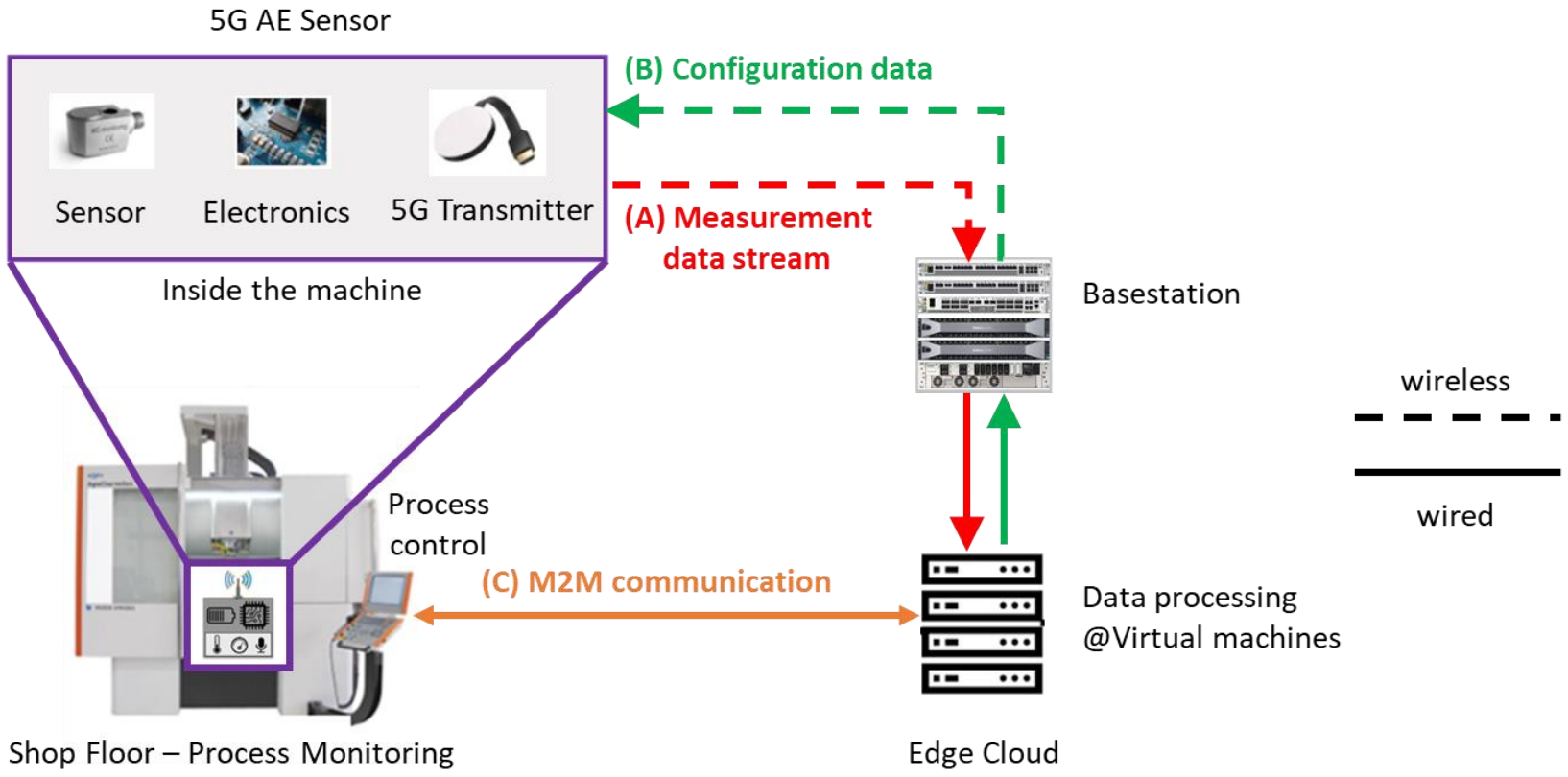
5G Wireless Acoustic Emission Measurement System – Integration Concept



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Conclusion and outlook

Conclusion

- 5G offers large potential for production
- Industrial 5G campus networks can be realized today
- 5G ecosystems still has to be shaped
- 5G-Industry Campus Europe is a collaborative platform to stimulate 5G innovations

Outlook

- 5G ecosystem requires joint efforts from IT and OT industry
- 5G development is ongoing and will enable future capabilities


5G
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