NOKIA Bell Labs

5G in manufacturing

2019 EU-US Frontiers of Engineering Symposium

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Agenda

- The way towards 5G (in manufacturing)
- 5G in manufacturing
  - Opportunities
  - Challenges
- Timeline
- Arena2036 – research campus for the two worlds to come together
- 5G beyond communcations
  - Localization
- 2 video segments
  - „latency matters“
  - Industry4.0@Nokia

The way towards 5G
Digital wireless cellular technologies - evolution

2G

GSM, CDMA2000

voice
messaging

UMTS, HSPA

voice
data

4G

Mobile BroadBand (MBB)
massive Machine Type Communication (mMTC)

enhanced Mobile BroadBand (eMBB)
Ultra-Reliable Low Latrency Communications (URLLC)
massive Machine Type Communication (mMTC)

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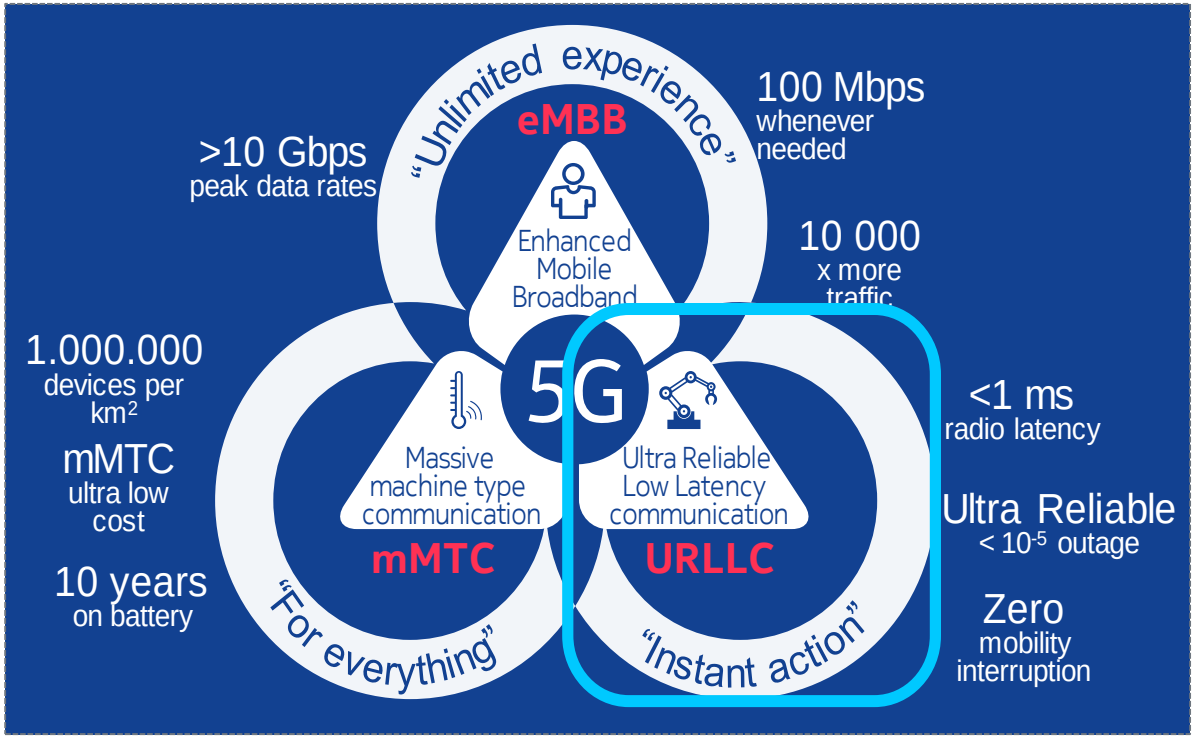
The way towards 5G
5G – more than just faster data



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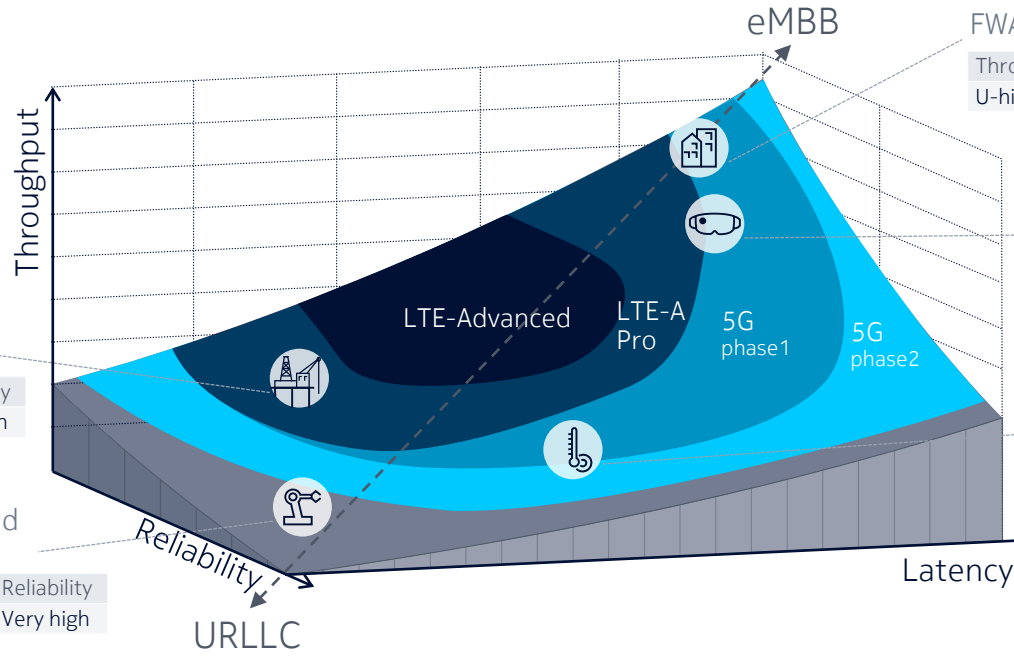
Opportunity: 5G NR is positioned to support a wide range of characteristics

Reliability, latency, and throughput requirements

NR … New Radio



FWA

Throughput	Latency B.	Reliability
U-high	15-200 ms	Medium

Immersive 360

Throughput	Latency B.	Reliability
UL: U-high / DL: high	50-100 ms	Medium/high

Mobile Tele-Operation (Vehicle and drone)

Throughput	Latency B.	Reliability
Varies	1-10 ms	Very high

eMTC with massive number of devices

Throughput	Latency B.	Reliability
Low	10-100 ms	High

Industry robotics and automation

Throughput	Latency B.	Reliability
Varies	1-10 ms	Very high

5G NR: the only radio technology to simultaneously provide high reliability & low latency

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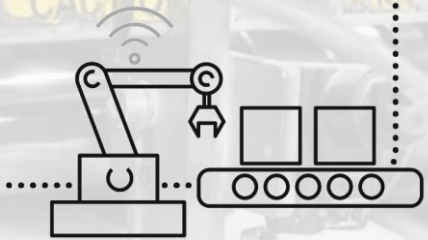
Opportunity: 5G NR to solve today's challenges of manufacturing industry

Increase flexibility and agility to quickly change production lines and introduce new products

Fluid Production



Automate processes more, to gain **efficiency**

Maximize **uptime** to minimize business interruption

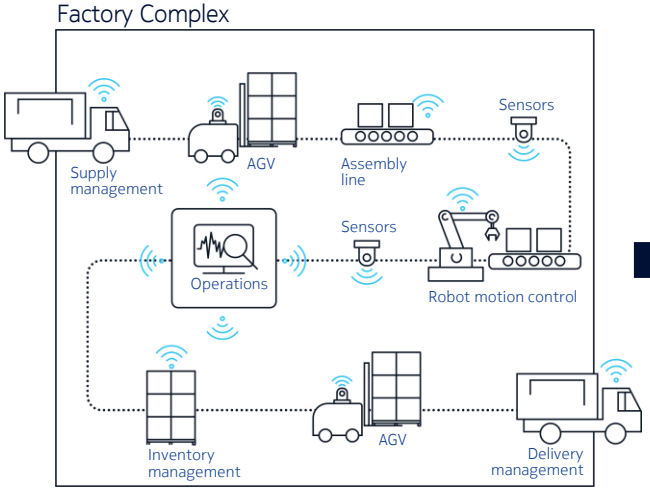
Increase human–machine **collaborative interworking** without compromising safety

Reduce **carbon emissions** and energy consumption

Realtime digital twin augmented reality

- Machine tech virtual world embedded within the digital world
- High capacity at low latency
- High precision localization
- Imaging
- Wireline replacement

5G in manufacturing
Use cases and their wide range of requirements



Use case	Reliability	Latency	Data Rate
Motion control	99.9999%	1ms	1 – 10 Mbps
Mobile robots / AGV	99.9999%	1-50ms	1 – 10 Mbps
Augmented reality	99.9999%	1-5ms	5-25 Mbps
Video assisted application	99.99%	10ms	10-25 Mbps
Industrial sensor	99.99%	10-30ms	1 Mbps
Process automation – monitoring	99.9%	50ms	1 Mbps
Video	99.9%	100ms	1 – 10 Mbps
Voice	99.9%	100ms	20 kbps
Field sensor / instrumentation	99.9%	10sec	10 kbps
Emergency safety notification	99.9%	10sec	0.1-20 kbps
Asset tracking	99.9%	10sec	0.1-20 kbps

99.9% … 99.9999%
1 ms … 10 sec
0.1 kbps … 25 Mbps

5G in manufacturing
Opportunities

- Widens the market of digital wireless cellular communications.
- Enables **digital twin** (digital representation of the factory floor).
- Enables „**fluid production**“ (regular and efficient factory floor rerangement).
- Opens locations to a wider range of **product variations**.
- Integrating the communication system and the factory floor management opens up new ways of system operation, e.g. by **exchanging context** between the two subsystems.
  - Radio coverage map.
  - Factory map, movement patterns.
  - Process periodicities
  - State of the network, state of the factory floor.
  - Time of the day, production floor schedule.

5G in Manufacturing
Challenges

- Change of **value chain. Business/operation model** to be defined
  - Traditional:
    - system design (e.g. Nokia, Ericsson) → system operation (e.g. Verizon, Telia) → system usage (smart-phones)
  - Key changes with 5G in manufacturing:
    - additional player: factory floor owner (system owner and eventually system operation)
    - System usage: factory floor equipment (much more diverse)
- **Market** is much more **granular and fragmented** (many small private/regional networks instead of few big national)
- Steep **learning curve**:
  - ICT (Information and Communication Technology) industry needs to learn about relevant characteristics of the new setting
  - OT (Operational Technology) industry needs to learn about the capabilities (and non-capabilities) of 5G
- Much wider **range of characteristics** for the communication system to meet

5G in Manufacturing
Some key challenges detailed

“Much wider range of characteristics for the communication system to meet”

- Lower latencies
- Higher reliabilities
- Strict determinism
- Industrial protocols are ethernet based, while 4G and initial 5G serves IP networks (IP … Internet Protocol)
- Smaller scale, more fragmented and diverse
- Mix of service categories present (eMBB, mMTC, URLLC)
- Cluttered industrial floor, many metallic surfaces

“Business/operation model to be defined”

- Two models of service operation discussed:
  - Traditional service operator “in the middle”
  - Factory floor owner = system operator

5G in Manufacturing

Some key technologies for reducing latency and increasing reliability

- **Low latency**
  - avoid lengthy hand-shakes between device and network
    - Technical implementation options: protocol design
  - smaller transmission granularities
    - Technical implementation options: frame design
  - move processing closer to the device
    - Technical implementation options: edge clouds

- **High reliability**
  - „Make assurance double sure!“, allow for several concurrent connections
    - Technical implementation options: multi-connectivity
  - „Better save than sorry“, no maximization of throughput at all cost
    - Technical implementation options: conservative link adaptation (configuration of the transmission)

Timeline - Realizing the full promise of 5G through 3GPP evolution

"Rome wasn't built in a day" – 5G evolves from a strong Rel-15 base

Q3 2017 – Q4 2018

Release 15

- Flexible 5G New Radio
- 5G Cloud Native Core
- End-to-end Network Slicing
- mmW frequency territory

Q4 2018 – Q1 2020

Release 16

- Industrial IoT foundation
- Wireless Wireline Convergence
- Non Public Networks (aka Private)
- 5G NR for Unlicensed Bands

starts Q1 2020

Release 17

- NR-Light foundation
- 3D-Expansion in Mobility & Altitude
- Analytics powered 5G networks
- 5G NR for >52.6 GHz

New release about every 18 months; Release 15 is the first „5G-release" with strong focus on traditional markets.
(Release 8 – introducing LTE – took 4 years.)

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https://www.arena2036.de/de/

Arena2036 – research campus for the two worlds to come together

ARENA2036

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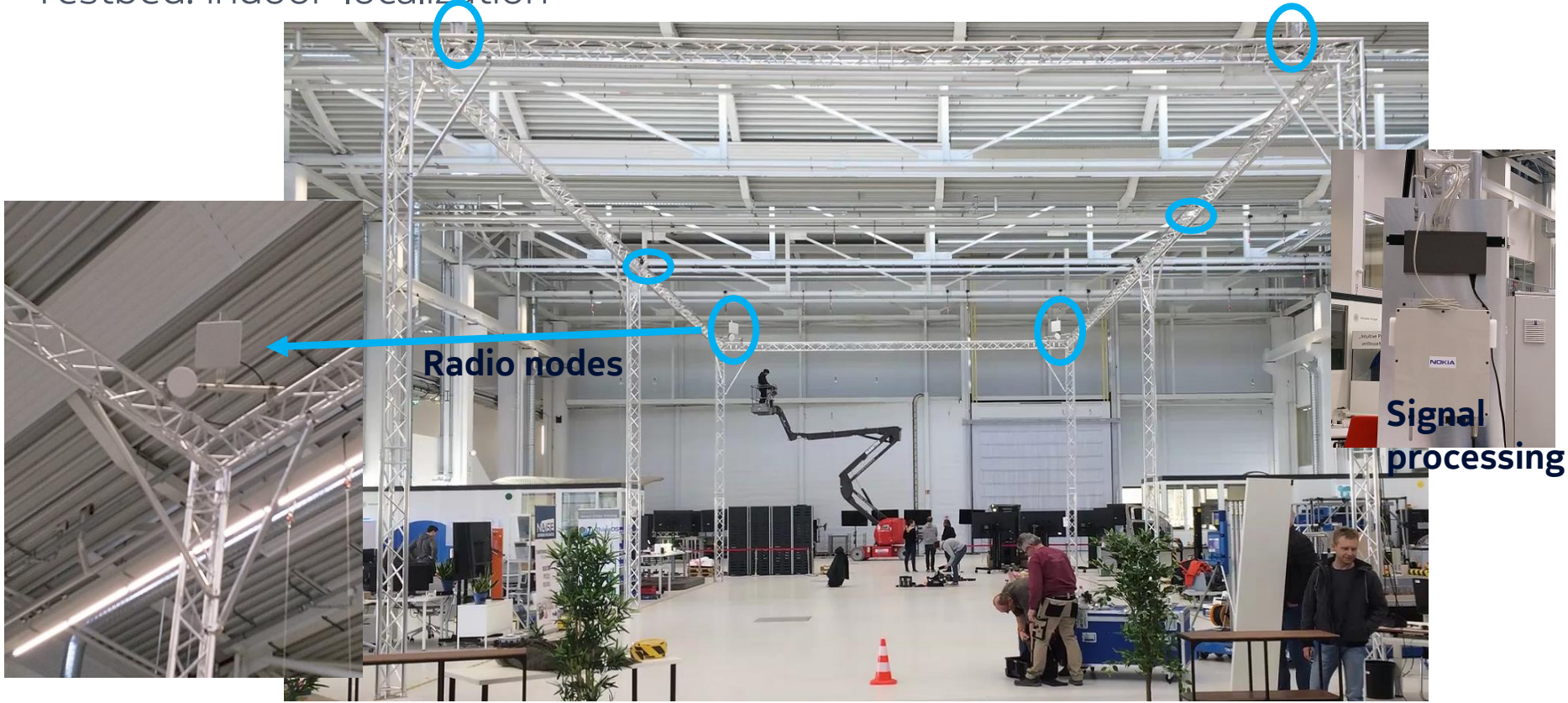
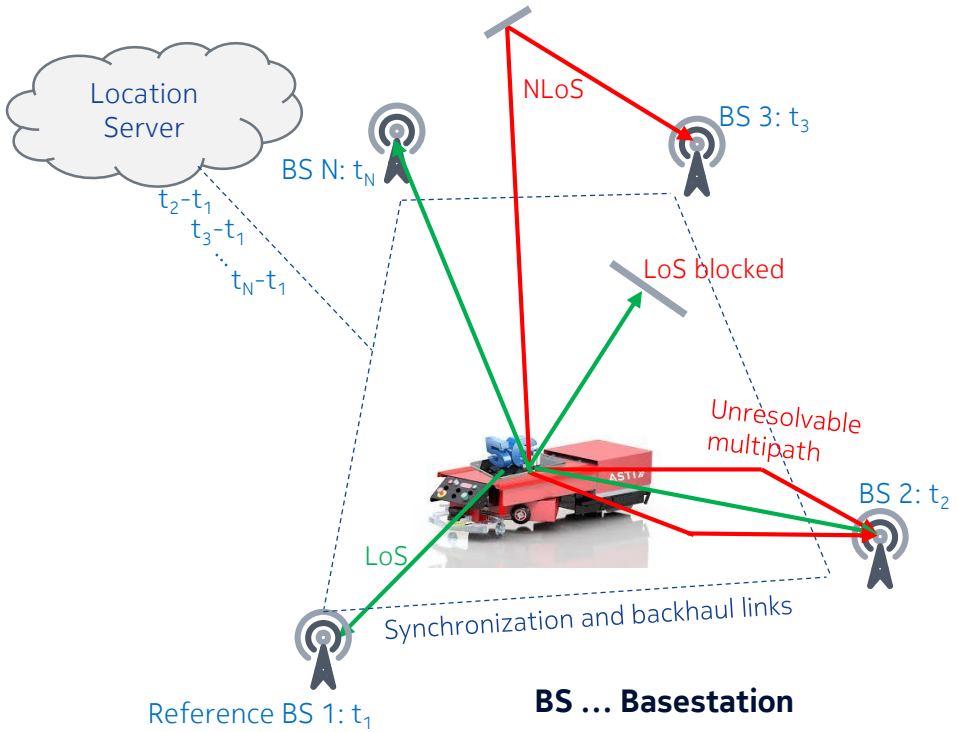
Testbed: indoor-localization



5G beyond communications
localization

- Item to be localized transmits predefined signal
- N (N>3) receivers detect the transmission
- Time of Arrival (ToA) calculated by each receiver
- ToAs collected by the location server
- Triangulation based localization estimate.



BS … Basestation
(N)LoS … (Non-)Line-of-Sight

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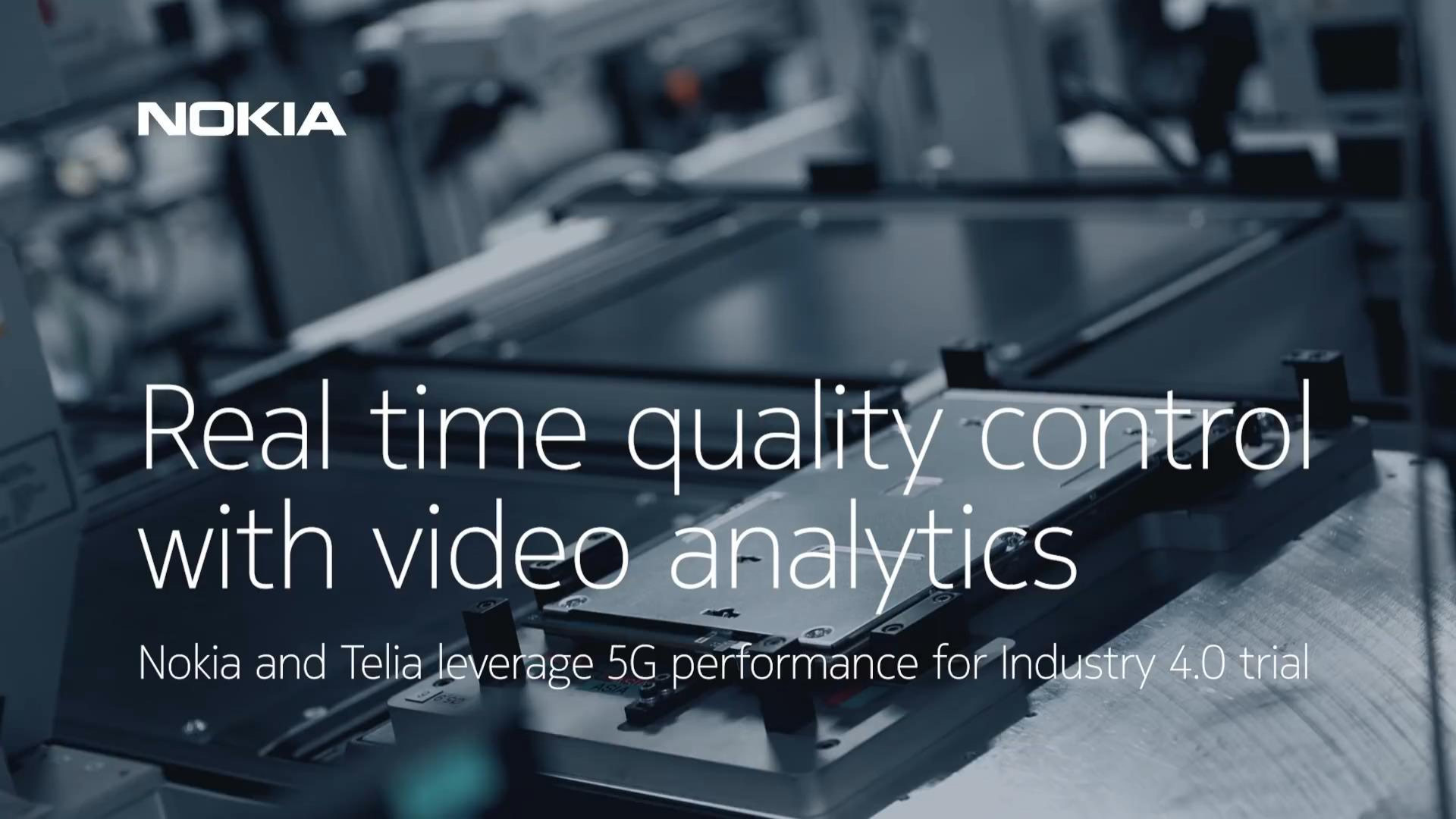
Video segment

„Latency matters“

Industry4.0@Nokia - Edge processing, real time video analytics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Real time quality control with video analytics
Nokia and Telia leverage 5G performance for Industry 4.0 trial

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