Industrial Private Wireless 4G/5G

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Why Industrial Private Wireless?
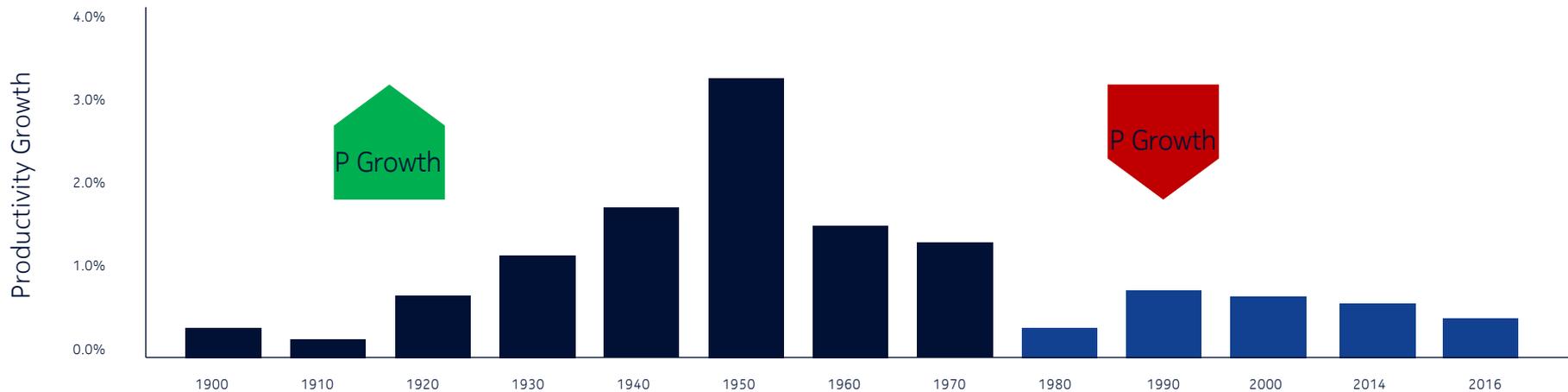
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First Industrial Revolution

Second Industrial Revolution

Third Industrial Revolution

Productivity Growth

1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2014	2016

P Growth

P Growth

Source: *The rise and fall of American Growth*, Robert Gordon

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Reliable Wireless Connectivity is Critical for 4th Industrial Revolution

Process Automation

Worker Interaction

Digital Intelligence

AUGMENT ANALYSIS

OPTIMIZE OUTCOMES

Today up to 90% of data are not collected in industrial campuses…
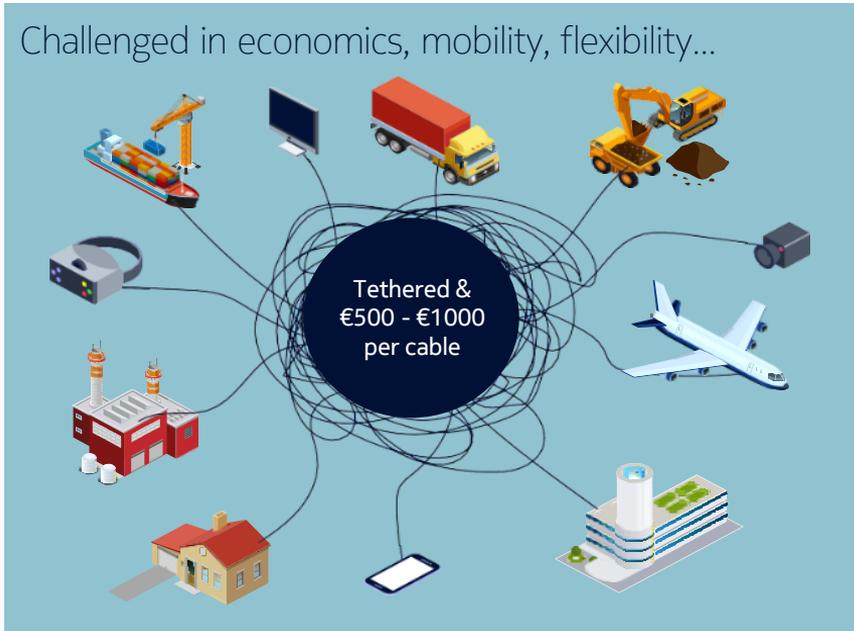
SENSE STATE

AFFECT ACTIONS

You can't control, digitalize and act upon what you do not observe…

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Current connectivity options are not sufficient for I4.0

*"43% of European enterprises consider **network transformation to be a key challenge** [..] recognizing that **current networks cannot support the future growth** [...] in areas such as **IoT and digital transformation**"*

LAN cables & other wired technologies
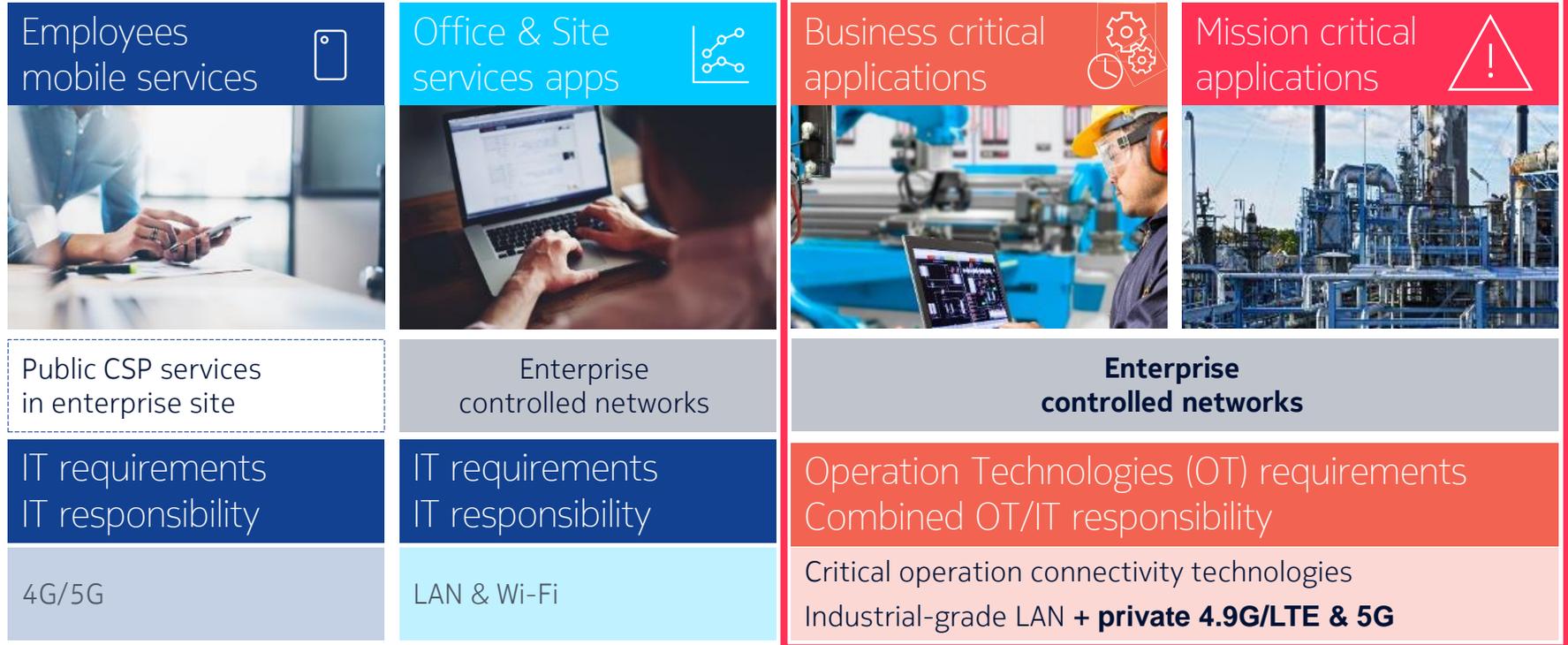
Challenged in economics, mobility, flexibility…

Tethered & €500 - €1000 per cable

Current wireless technologies challenges

	P25 / TETRA	WiFi 802.11ac	WirelessHART	sigfox / LoRa	Bluetooth	Lte / 5G
Security	■		■	■		■
Reliability	■					■
High data-rate / low latency		■				■
Predictable performance	■					■
Coverage				■		■
LP-WAN			■	■	■	■
Mobile	■					■
Voice	■		■			■

*IDC, European Enterprise Communications Survey, 2019

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Different application domains in same industrial site
Different technologies for different requirements

Employees mobile services	Office & Site services apps	Business critical applications	Mission critical applications
Public CSP services in enterprise site	Enterprise controlled networks	**Enterprise controlled networks**	
IT requirements IT responsibility	IT requirements IT responsibility	Operation Technologies (OT) requirements Combined OT/IT responsibility	
4G/5G	LAN & Wi-Fi	Critical operation connectivity technologies Industrial-grade LAN **+ private 4.9G/LTE & 5G**	

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Nokia Private Wireless Solution

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World 1st commercial 5G SA private wireless solutions

Digital Automation Cloud

Integrated **Plug&Play as-a-service** solution comprising of **Digitalization platform** with ready-to-run applications

Edge Cloud Server

Modular Private Wireless

End-to-end customizable solution for most **demanding enterprise requirements**
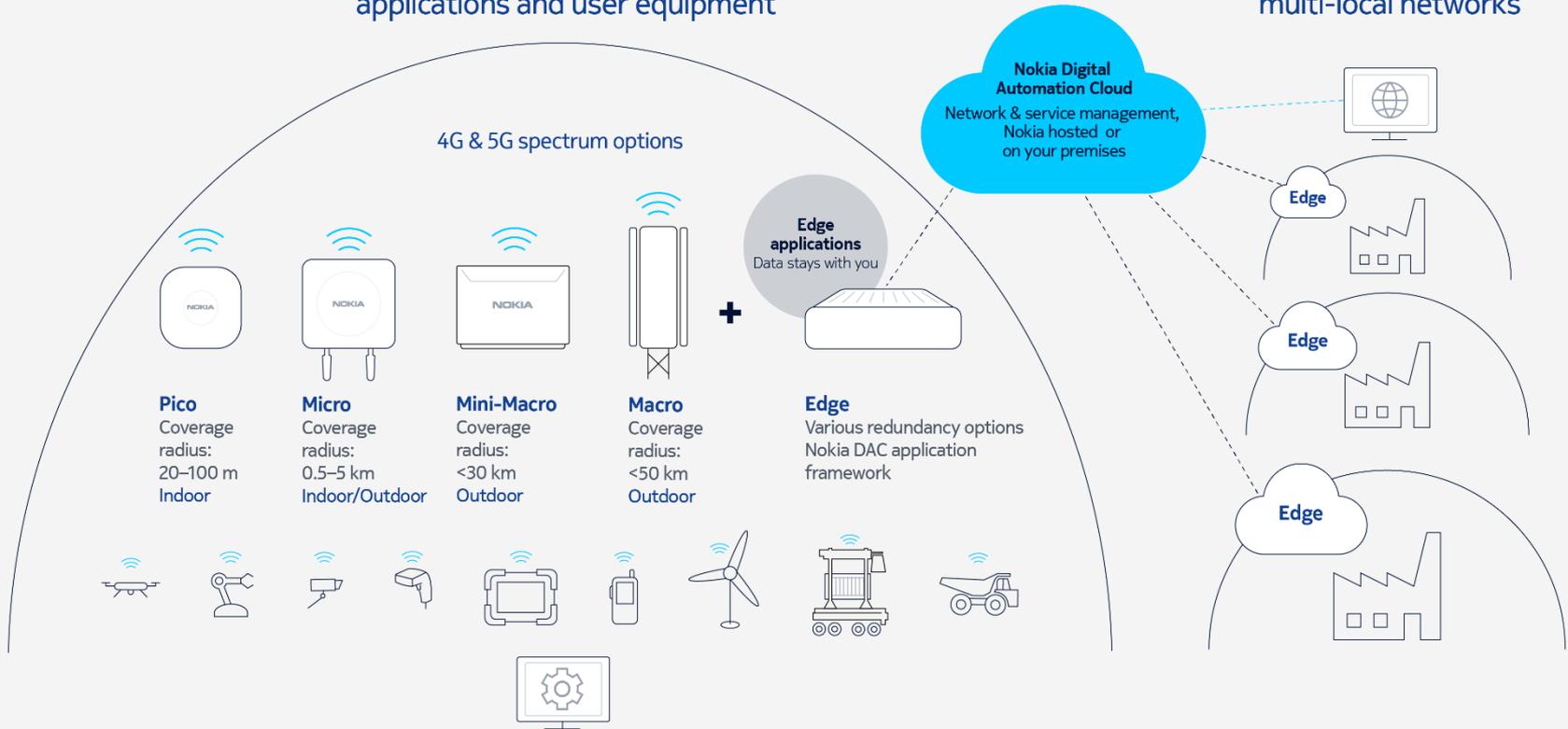
Full Core network

5G radio solutions

Stable and commercial software grade solutions

- Supports customers in market with 5G vertical spectrum or enterprise that wants to start pW with 5G
- Help drive the development of future 5G ecosystem
- Future proof support for future 5G 3GPP releases
- Ability to add 5G to 4.9G/LTE deployments

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Nokia Digital Automation Cloud – Plug & Play Private 5G

Comes with spectrum, edge computing, access points, applications and user equipment

Lets you create and manage multi-local networks

Nokia Digital Automation Cloud
Network & service management, Nokia hosted or on your premises

4G & 5G spectrum options

Edge applications
Data stays with you

Edge

Edge

Edge

Pico
Coverage radius:
20–100 m
Indoor

Micro
Coverage radius:
0.5–5 km
Indoor/Outdoor

Mini-Macro
Coverage radius:
<30 km
Outdoor

Macro
Coverage radius:
<50 km
Outdoor

+

Edge
Various redundancy options
Nokia DAC application framework

Nokia DAC device management + Nokia DAC catalog

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Nokia Digital Automation Cloud Application & Device Ecosystem
Out-of-the-box applications and robust devices pre-integrated and available

Voice & Video Communication

NDAC Application | Voice, Video and Text Communication
Serving various (business-critical) communication needs

Advanced Video Analytics

NDAC Application | Connected Video Analytics
View, analyze and act on identified objects and patterns

High Accuracy Indoor Positioning

NDAC Application | High Accuracy Indoor Positioning (HAIP)
View asset location in real-time and browse through history data

Nokia Drone Networks

NDAC Application | Nokia Drone Networks
An industrial grade connected UAV solution

Industrial Connectors & Protocols

NDAC Application | Industrial Protocol
Support of L2-to-L3 mapping for PROFINET and SCADA protocols
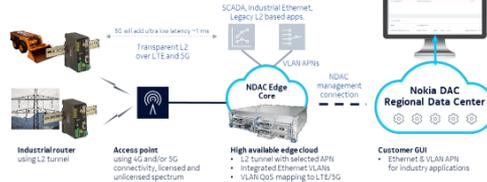
Industrial-grade Devices

Nokia Digital Automation Cloud | Industrial Device Ecosystem
E2E solution with robust, performing and easy to manage device portfolio

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Major analysts have endorsed Nokia as market leader in Private Wireless

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WiFi vs. Private Wireless

WiFi 6: Better capacity, latency and data rate but still IT centric...
Private 4G/LTE and 5G fit for OT application requirements

Wide and deep coverage

4-100x coverage
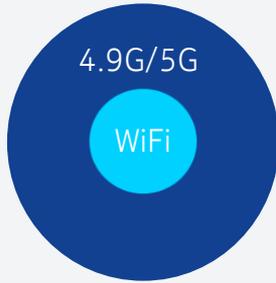
4.9G/5G

WiFi

>3 extra walls of penetration
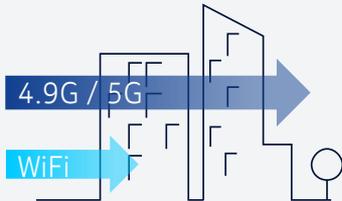
4.9G / 5G

WiFi

Predictable performance

Stable <15ms latency

Latency / Jitter

Wi-Fi

LTE

Loading/Users

25x multi-user capacity

Cell throughput

LTE

Wi-Fi

Loading/Users
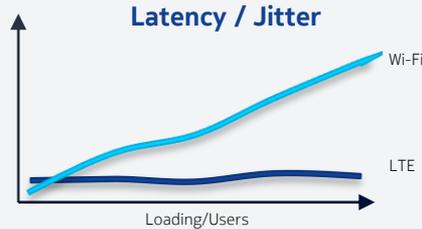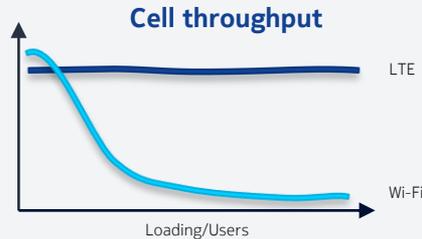
Military grade security

HACKED

Wi-Fi – WPA2/3

4.9G/5G
SIM authentication
E2E encryption

One network for all apps

Wi-Fi 5/6
• Does not include IIoT LP capabilities

LTE integrates LPWAN
• Narrow band, low power applications on same radio

LTE-M   NB-IoT

High speed mobility

WiFi

Up to **15 sec** latency on fast hand-over
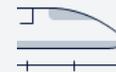
4.9G/5G

Smooth hand over up to **350kph**

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Addressable Market

The market for industrial site private wireless demands experience, solution flexibility and partner ecosystem

Requirements vary significantly by segment

Source: Harbor Research

Transport venues and ports: 50K

Military bases: 10K

Warehouses: 3.3M

Industrial and manufacturing: 10.7M

Oil and gas: 8K

Power generation: 47K

Mining: 54K

Water utility plants: 140K

Hospitals and labs: 263K

Total : 14.5M

7M
Networks/
macro BTS

14M
Global
industry
sites

Economic value of IoT by 2025

$3.8T to $11T

Source: McKinsey

Up to 11%

of global economy in 2025

Source: McKinsey

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Spectrum Licensing for Industries

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Spectrum Bands in Switzerland

380-400: Tetrapol

410-470: Walky-Talky

873-880: GSM-R

880-960: GSM/UMTS

960-1.5: Mil, Navigation

1.42-1.51: LTE Operators

2.2-2.4: Satcom; Amateur WLAN, Bluetooth

2.5-2.7: LTE Operators

2.7-3.4: Airnavication /Radar Civil & Mild

5.1-5.7: WLAN Unlicensed LTE and 5G

>6 Satcom; Earth exploration; Microwave

26G: 5G mmWave Candidate for pWireless

698-703: Authorities
733-736: Authorities

703-788: 5G Operators

791-862: LTE Operators

1.5-1.7: Satcom

1.7-1.9: LTE Operators

1900-1910: FRMCS

1920-2200: UMTS Operators

3.4-3.5: Wireless Cameras Candidate for pWireless

3.5-3.8: 5G Operators

3.8-4.2: Satcom

4.2-5.1: Satcom, Navigation Radar UWB

Legend:
- Busy (red)
- Free (green)
- TV (blue)
- Military (olive)
- Other (grey)

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References & Use-cases

420+ private wireless customers
Uncontested market leader in private wireless*

*Supported by latest publicly released data from key analysts firms

Public references

Recent new logos

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Nokia selected by NASA to build first ever cellular network on the Moon

NASA selected Nokia as a partner to advance "Tipping Point" technologies that will foster the development of commercial space capabilities and benefit future NASA missions.

Nokia will deploy the first LTE/4G communications system in space, providing critical communication capabilities on the lunar surface.

Nokia's lunar network consists of an LTE Base Station with integrated Evolved Packet Core (EPC) functionalities, LTE User Equipment, RF antennas and high-reliability operations and maintenance (O&M) control software. The solution has been specially designed to withstand the harsh conditions of the launch and lunar landing, and to operate in the extreme conditions of space.
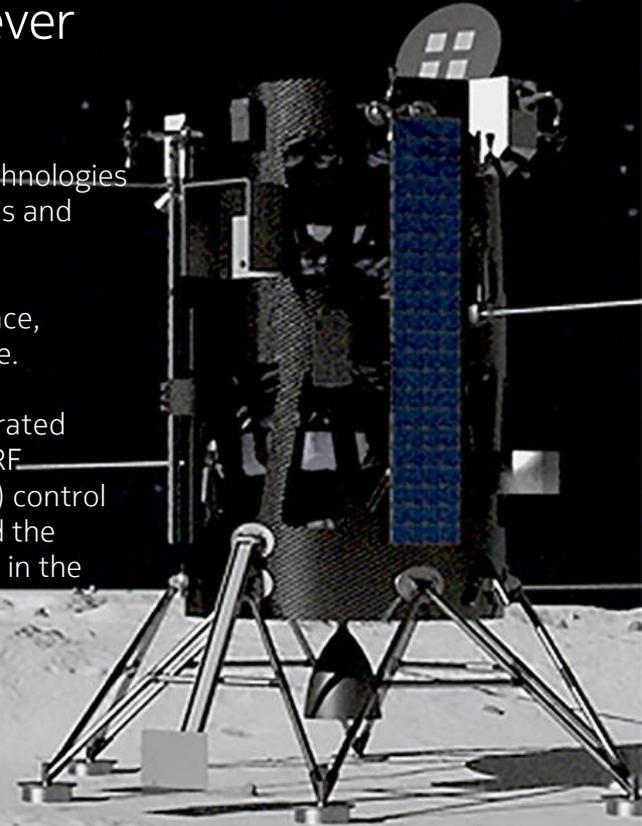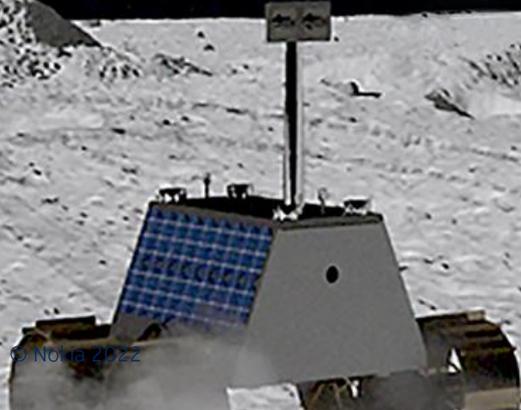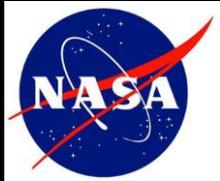
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Nokia's conscious factory of the future in Oulu leverages private 4G/5G for shop floor automation

Welcome to Nokia Oulu Factory
Advanced 4th Industrial Revolution Lighthouse

Nokia Conscious Factory @ Oulu
- New product introduction (NPI) factory, manufacturing 4G and 5G network equipment along multiple SMT production lanes
- Oulu as "Home of Radio" – Radio R&D incl. 6G
- Digitalization and automation since 2014 towards the conscious factory of the future
- Award-winning live lab, Industry 4.0 lighthouse

Use Cases & Private Wireless
- 100% of production area covered with 4G and 5G private wireless network including edge computing and redundancy
- Flexibility, mobility and reliability leveraged by use cases such as
  - Dynamic shop floor layout
  - Flexible robotics & real-time process mgmt.
  - Asset connectivity, monitoring and control
  - Cloud-based digital twin & virtualization

Business Benefits
- Optimized production layout change time
- Increased material feed operation efficiency
- Higher overall equipment effectiveness (OEE)
- Plus in product quality and manufacturing productivity
- Reduced prototype lead time and assembly defects

Press Release & Resources: https://www.nokia.com/about-us/news/releases/2019/07/03/nokias-digitalization-of-its-5g-oulu-factory-recognized-by-the-world-economic-forum-as-an-advanced-4th-industrial-revolution-lighthouse/
Video: https://youtu.be/I9gw7I0C-gE

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stürmsfs smart manufacturing with NDAC 5G

stürmsfs

- stürmsfs is one of the leading suppliers of quality steel and metal products located in Switzerland and Austria.
- Focused on digitalization and process optimization NDAC 5G will enable to connect all the relevant assets, tools and workers in the factory.
- In partnership with the IndustryFusion Foundation (who focuses on open source and open interface solutions for SME) and Intel pioneering solutions for the smart factory of the future will be developed.

Use Cases & Private Wireless

- Monitor and control of the cutting systems
- Connected cranes and forklifts
- Smart loading of the trucks
- Connected workers
- Outlook: Deployments in every factory

Business Benefits

- Process and production optimization by connecting devices via standardized open interfaces based on I4.0 admin shell
- Proof for the application of a vendor agnostic framework for process monitoring and control

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Bosch deployed 5G private wireless in their plant in Stuttgart-Feuerbach for Industry 4.0 use cases

Bosch
- Leading global technology provider focusing on mobility, industrial solutions, IoT, energy and building solutions, headquartered in Germany
- Blueprint factory in Stuttgart-Feuerbach selected for 5G trial to prepare global rollout to 270 factories globally
- Long-lasting Nokia partnership through Nokia Bell Labs research projects and ARENA2036

Use Cases & Private Wireless
- Fully-fledged 5G private wireless network deployed, based on Nokia Digital Automation Cloud and local enterprise spectrum
- Transform Bosch factories, but also blueprint the smart factory of the future
- Industrial use case incubation includes
  - Automated guided vehicles
  - Wireless safety applications
  - Human machine interaction
  - Advanced and cloud robotics
  - Predictive maintenance
- Outlook: Artificial Intelligence, ML

Business Benefits
- Improve production efficiency, human and machine safety, shop floor flexibility, sustainability and more

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Volkswagen tests 5G for production on its way to smart factories

Super fast, secure and extremely flexible
Volkswagen is testing 5G for production

- Extremely short response time of up to 1 millisecond
- Highly reliable for greater utilisation
- Data transfer at speeds of a gigabit

5G

flexible software flashing

Reliable data entry

Real-time control

Volkswagen Press Release:
https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-tests-5g-for-production-on-its-way-to-smart-factories-7570

Interview / Video:
https://shaping-mobility.volkswagen.com/de/storys/5g-fuer-die-voll-vernetzte-fabrik-der-zukunft-14847

Volkswagen
- Leading global car manufacturer
- Pilot project at the Wolfsburg plant: Volkswagen launches local 5G network for its production operations

Use Cases & Private Wireless
- Full 5G private wireless network coverage, based on Nokia Digital Automation Cloud
- Testing of pre-defined use cases to optimize existing production processes & be prepared for upcoming further automation
- Co-creation and validation of industrial 5G use cases such as
  - screwdriver connectivity & data collection
  - connectivity of smart devices for system monitoring and remote control
  - Data shower to cars and Robots/AGVs to update control units

Business Benefits
- Leverage lessons learned for process design and factory blueprints to roll out globally
- Expected business benefits on the long run:
  - Reducing downtime due to stable wireless connectivity
  - Savings on additional WLAN access points & less wires

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Japanese construction company uses private 5G for remote control of tunnel drilling operations

Japanese Construction Company
- Major construction company in Japan
- Constructs dams, roads, airports and railroads for large-scale civil engineering projects as well as builds residential, commercial, institutional, and industrial buildings

Use Cases & Private Wireless
- 5G private wireless connectivity using Nokia's Digital Automation Cloud (NDAC) and solution partner Fujitsu
- Leading use case: Remote controlling and monitoring of drilling operations in harsh environments
- Additional use cases include
  - Autonomous vehicle guidance
  - 4k video streaming and monitoring
  - Remote controlling of additional machines

Business Benefits
- Optimized operations using remote control and key activities' supervision
- High performance connectivity for critical communication use cases in harsh and "difficult to reach" coverage areas
- Increased worker safety through remote video monitoring

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100s of Alibaba's AGVs connected with private wireless network in Cainiao operated warehouse

Video: https://www.youtube.com/watch?v=VLE9XROd9fo

Alibaba @ China
- Chinese multinational company specialized in eCommerce, retail, internet and technology
- World's largest retailer/e-commerce company
- Cainiao Network is a smart logistics network and data platform of Alibaba to meet Alibaba's logistics vision of fulfilling customer orders

Use Cases & Private Wireless
- Warehouse with over 700 AGVs (autonomous guided vehicles) working in a 30 000 sqm area
- Private wireless network using unlicensed spectrum to connect more than 100 AGVs
- Use cases beyond AGVs:
  - IoT applications
  - Big data
  - Edge computing and artificial intelligence

Business Benefits
- Efficiency increase for warehouse machinery applications
- Communication delay reduced from 60-1000ms to 12-20ms
- 90% less wireless APs compared to WiFi
- Boost IoT applications with higher data transfer accuracy and without delay

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BASF leverages private 5G capabilities for traffic and staff management at Tarragona plant in Spain

BASF Spain @ Tarragona Plant
- BASF is a Germany-based, multinational chemical manufacturer with a ~1 km² petro-chemical plant in Tarragona/Spain
- Production of detergents, cosmetics, plastics and fungicides
- BASF globally operates in 80+ countries with plants in Europe, Asia, Australia, the Americas and Africa

Use Cases & Private Wireless
- 5G private network using Nokia's radio portfolio and a centralized core, deployed and operated by Spanish CSP Cellnex, in Madrid
- Use cases include:
  - Traffic management and truck guidance for logistics optimization purposes
  - Staff localization
  - Virtual and augmented reality
  - Big data and artificial intelligence

Business Benefits
- Optimize operations, in particular logistics, and significant decrease in operational costs
- Enhance plant security and staff safety on-site
- Reliable and high-performance communication with full coverage across the whole site

Press Release: https://www.cellnextelecom.com/en/basf-and-cellnex-will-bring-5g-technology-to-the-tarragona-production-centre/

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Butachimie leverages private 4G network for CCTV, Push-to-Talk, IoT sensing and asset management

La connectivité au service de la digitalisation et de l'industrie 4.0

Butachimie (INVISTA + BASF)
- Key player in chemical manufacturing, especially polyamide intermediates, technical plastics, textile, industrial fibers and high-tech coatings
- Consumers include automotive, textile, home equipment and consumer good industries

Use Cases & Private Wireless
- 4G private wireless using Nokia's radio and core portfolio, offered with spectrum via Orange Business Services (OBS)
- Use cases to support the campus evolution towards Industry 4.0:
  - CCTV for access and process control
  - Push-to-Talk / Push-to-Video communication
  - IoT sensors for condition monitoring
  - Geolocation of assets
  - Scalable, secure and efficient connectivity (performance testing and assessment)

Business Benefits
- Production cost reduction and generation of new sources of income
- Process simplification while respecting security, sustainability and flexibility (scalability) along the production chain
- Enablement for IoT and Industry 4.0 apps

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Private 5G helps Nissan to remove driver and allow for remote teleoperations at Sunderland test track

Nissan & Consortium

- Connected Automated Logistics pilot with The North East Automotive Alliance (NEAA), Sunderland City Council, Newcastle University, Coventry University, Connected Places Catapult, StreetDrone and Perform Green

Use Cases & Private Wireless

- 5G SA private wireless network deployed, based on Nokia Digital Automation Cloud and local UK enterprise spectrum
- Enablement to remove the driver from the process and allow for remote teleoperations to control the vehicles which can carry up to 40t
- Artificial intelligence and advanced analytics to review, stress test and hone 5G technology
- Setup of the consortium
  - 12- to 18-months test period
  - Ensure the system is fit for purpose and pro- tected from threats like security breaches
  - Create a blueprint for similar projects

Business Benefits

- Be the leader in trialing autonomous connected logistics in UK
- Increase productivity and safety between various areas of the Nissan plant

Press Release: https://north.tech/news-insights/pioneering-pilot-to-bring-ground-breaking-5g-technology-to-life-for-the-first-time/

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Lufthansa Technik uses 5G private wireless for virtual table inspection of plane engine parts
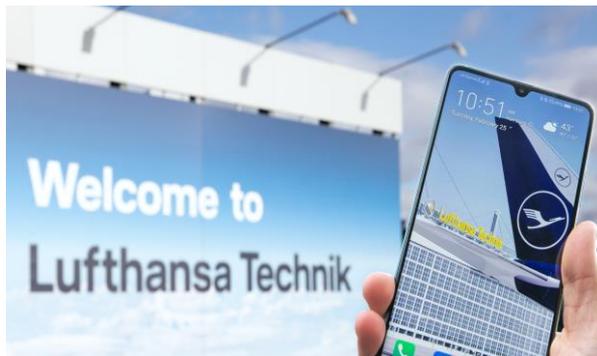
Lufthansa Technik

Lufthansa Technik
- One of the leading providers of technical aircraft services globally
- 35 subsidiaries provide digital fleet support, maintenance, repair, overhaul, modification, completion and manufacturing of aircraft, engines, components and landing gear

Use Cases & Private Wireless
- 5G private wireless network deployed in Lufthansa's Hamburg facility for high-bandwidth use cases
- Use case #1: Virtual table inspection
  - Lufthansa's clients can do remote inspection of engine parts using HD video streaming
  - Virtual table inspection of disassembled parts and joint decision making upon maintenance
  - Previous 4G and Wi-Fi technologies could not fulfill the very high bandwidth demand
- Use case #2: Virtual cabin modification Lufthansa can modify cabin designs virtually with VR/AR to fit their client's requirements

Business Benefits
- Remove the need for customer's clients to physically attend engine overhaul procedures
- Increase maintenance efficiency and productivity

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Photos: © Lufthansa Technik AG, Jan Brandes
Press Release:
https://www.nokia.com/about-us/news/releases/2020/02/27/nokia-deploys-5g-private-wireless-network-for-lufthansa-technik-virtual-inspection-trial/

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Verticals adopting private Wireless

Aviation, Air Traffic & Space

Highways

Maritime & Ports

Rail & Metro

Mining

Oil & Gas

Power Utilities

Water Utilities

Education

Defense

Public Safety

Smart Cities

Automotive

Discrete Manufacturing

Process Manufacturing

Logistics

Healthcare

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