5G Anwendungen in der Praxis

Nokia Enterprise
@MartinBeltrop, martin.Beltrop@nokia.com
What our customers need from us today

**Automated falling conductor disconnect** to avoid fire

**Fix Wi-Fi related autonomous truck crashes**, downtime & resulting wear & tear

**Maintain grid reliability** with growing distributed renewables / storage

**Wind turbine monitoring** for predictive maintenance

**FAN convergence and automation**

**Connectivity inside the plane** (pilots, crew, workers, etc.)

**Plane departure time prediction using cameras & analytics**

**Automated site access system and parameter security**

**Reefer monitoring**

**Remote control, autonomous cranes and AGV**

**Real-time work-order system** for cranes & truck drivers

**Replace Wi-Fi and PMR for reliable airfield marshal work-orders & PTT**

**Drivers’ tiredness monitoring**

**Connectivity inside the plane** (pilots, crew, workers, etc.)

**Grid imposed low speed & reliability issues**

**Plane departure time prediction using cameras & analytics**

**Real-time work-order system** for cranes & truck drivers

**Automated site access system and parameter security**

**Reefer monitoring**

**Remote control, autonomous cranes and AGV**

**Legacy assets digitalization for predictive maintenance**

**Fix AGV Wi-Fi imposed low speed & reliability issues**

**Digital twin Machine connectivity**

**Workers’ connected tools & safety**

**“Lot-size one” manufacturing**
Nokia’s making it happen now!
Nokia Private wireless customers
From 80 wins in Q2

120+ enterprises deploying Nokia private wireless in their premises
+ 22 GSM-R networks, poised for private LTE/FRMCS upgrade

Public wins
Our end-2-end solution
Customer networking needs extend beyond Radio & Core

Analysis of 2 real recent customer cases

### Autonomous Haulage for Mine

**Nokia solution components**

- 55 IP/MPLS End-points
- 42 Radio + 2 cores
- 23 Wireless Backhaul
- 46 IP/MPLS routers/optical
- End-to-End management & orchestration

### Power utility wireless FAN

**Nokia solution components**

- 69,000 End-points
- 450 Radio + 4 Cores
- 120 Wireless Backhaul
- 290 IP/MPLS routers/optical
- End-to-end management & orchestration
Comprehensive portfolio to support your needs
Private wireless but end-to-end at the essence

End points
- MulteFire & unlicensed LTE modems
- Ruggedized IP MPLS LTE routers
- Industrial terminal partner portfolio

Radio
- Small Cells BTS
  - LTE/4.9G & 5G
  - Indoor & Outdoor
  - 250mW, 5W & 20W
  - Up to 840 users per BTS
  - LTE-M, NB-IoT support
- AirScale Macro BTS

Backhaul/Transport
- Transport:
  - Mission critical IP
  - Optical
- Backhaul:
  - POL
  - Wireless Backhaul

Core
- CMU+EVC core

Services & Edge Apps
- Services
  - IoC, Labs (LaaS)
- Services
  - Space Time analytics
  - Group Communication

DAC as-a-service turnkey private wireless with integrated edge cloud & applications
- Edge cloud server
  - e.g. High Accuracy Indoor positioning

Single end-to-end management and orchestration
Our ways into the markets
Vertical specific blueprints
Developed by segment practices

- Business needs
  - Use cases 1 2 3
    - S/W IoT platform
    - Device eco-system
    - 3rd party systems
    - Peripheral technology

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  - Use cases 1 2 3
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    - Device eco-system
    - 3rd party systems
    - Peripheral technology

Common industrial-grade private wireless solution blueprints
Collaborating with entire ecosystem to drive Industry 4.0

**Service provider partners**
Expertise in building & operating mobile network or public clouds, spectrum partners

**Industrial ecosystem partners**
Kick starting the industry with more LTE and future 5G industrial connected things

**System integrators & Consulting**
Deeper industry expertise and specialised channel to market
Broadening the sphere of influence
Give me some examples
Energy - Mining
Australia, Rio Tinto 6x (expanding to 21x) Open-pit Mines

Initial application
Competitiveness in global mining industry:
- increasing safety & decreasing labor cost through best communications infrastructure
- improving operational productivity
- Video-based, remote-controlled and autonomous drilling operation

Additional applications:
Single mission critical wireless network for all mine workers, sensors and machines:
- CCTV, people & machines monitoring systems for real time operational view to increase efficiency, machine reliability and workers’ safety
- Remote operations from a single location (Perth)
- Autonomous mining platforms – drills, trucks and trains for improved operation efficiency & increased safety (fewer workers in dangerous areas)
- Group communications with PTT and PTV-over-video to enhancing communications and coordination

private LTE drivers
Creating a Mine of the Future™ required a single converged network for business, safety and production-critical systems
Wi-Fi struggled with mining environment and requirements:
- Mine size
- Need to limit equipment installed in pit
- Mobility needed
Initial application

Ship-to-shore gantry crane-mounted video cameras to record status of containers at arrival and after crane handling
- Inform end-customers early if container damaged
- Faster insurance treatment (clear responsibilities)

Other application(s) implemented afterwards

Video surveillance cameras covering the complete shipping yard
- Site security + improved efficiency via complete real time overview of site assets/people/vehicles

Connectivity to 150 trucks and vehicles mounted UE in harbour + warehouses
- Give workers and machines real visibility of status, next “job order”, etc...

Connectivity for “external” workers and machines
- Slicing for secure (and restricted) information access

Readiness for Port 4.0 – Self driving vehicles, etc…
Industrial - Manufacturing
Nokia Conscious Factory – Oulu, North Finland

This Oulu factory and lab is fascinating: I’ve never been to a factory like this before and am very impressed (Kosei Takiishi/Gartner).
How much does it cost
Beispielrechnung für die Kosten eines Campusnetzwerks

**Das kostet ein 5G-Campusnetz**

Beispielszenarien für den Ausbau von lokalen Netzen mit einer Laufzeit von 10 Jahren

<table>
<thead>
<tr>
<th>Produzierendes Unternehmen: ein Bürogebäude und zwei Produktionshallen</th>
<th>Anwendungsbereich: Industrie 4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Versorgungsfläche: 30 000 m² Siedlungs-/Verkehrsfläche</td>
<td></td>
</tr>
<tr>
<td>Bandbreite</td>
<td>Frequenzgebühr</td>
</tr>
<tr>
<td>30 MHz</td>
<td>1 500 €</td>
</tr>
<tr>
<td>Fußballstadion/Eventlocation mit 40 000 Zuschauerplätzen</td>
<td>Anwendungsbereich: Live-Übertragung und vernetzte Kameras</td>
</tr>
<tr>
<td>Versorgungsfläche: 40 000 m² Siedlungs-/Verkehrsfläche</td>
<td>Laufende Kosten für den Betrieb über 10 Jahre</td>
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<tr>
<td>100 MHz</td>
<td>2 000 €</td>
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<tr>
<td>Mittelgroßes Krankenhaus mit 1 000 Betten und drei Klinikgebäuden mit Außenflächen</td>
<td>Anwendungsbereich: vernetzte Patientenakten, Überwachung von Messgeräten und Robotern</td>
</tr>
<tr>
<td>Versorgungsfläche: 250 000 m² Siedlungs-/Verkehrsfläche</td>
<td></td>
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<tr>
<td>50 MHz</td>
<td>5 000 €</td>
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<tr>
<td>Landwirtschaftlicher Betrieb mit Tierhaltung und Feldern zur Produktion landwirtschaftlicher Erzeugnisse</td>
<td>Anwendungsbereich: genaues Ausbringen von Düngemittel, Steuerung von selbstfahrenden Traktoren</td>
</tr>
<tr>
<td>Versorgungsfläche: 5 km²</td>
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<tr>
<td>30 MHz</td>
<td>8 500 €</td>
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<tr>
<td>Flughafen mit Intralogistik mit Bürogebäude, Frachthallen und Außengelände</td>
<td>Anwendungsbereich: vernetzte Erfassung von Fracht und Sensoren</td>
</tr>
<tr>
<td>Versorgungsfläche: 15 km² Siedlungs-/Verkehrsfläche</td>
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<tr>
<td>50 MHz</td>
<td>225 000 €</td>
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</table>

**Quelle:** Handelsblatt 18. November 2019
Go Allwhere.

Networking solutions for the new age of industry.

nokia.com/networks/go-allwhere
Industry 4.0: The time is now
All stars align (digitalization needs, spectrum, ecosystem, solutions) to start NOW

Reliable wireless is critical for digitalization NOW!

- Private 4.9G
  - Major leap compared to Wi-Fi
  - >85% of industrial applications

Deployable solutions are ready NOW, 5G ready for NEXT

- Early 5G standards focusing on mobile broadband CSP deployments
- Expected terminals in 2022+
- R15
- R16/17
- R17/18

- Extreme Mobile Broadband
- Critical machine communication
- Vertical features
  - LTE-M & NB-IoT
  - Reliability, Latency & Slicing

- DL: 1.5Gbps
  - UL: 300Mbps

- Vertical features
  - Incl. m-IoT connectivity
  - Reliability 3-5x 9’s
  - Latency <10ms

- Machine communication
- Enhanced Mobile Broadband

- DL: 1.5Gbps
- UL: 300Mbps

- Low datarate / long battery life

- IoT & Sensors
- Extreme Mobile Broadband

- 10Gbps
Different application domains in same industrial site

Different technologies for different requirements

- Employees mobile services
- Public CSP services in enterprise site
- IT requirements
  - IT responsibility
  - 4G/5G
- Office & Site services apps
- Enterprise controlled networks
- Business critical applications
- Mission critical applications
- OT requirements
  - Combined OT/IT responsibility
  - Critical operation connectivity technologies
1st Step of industry 4.0
Digitalization by connecting all assets.

74% of today’s data not yet collected!
Critical operations require industrial-grade connectivity

Existing
- Security
- Reliability & availability
- Predictable high performance (data-rate and latency)

INDUSTRY 4.0 digitalization additional connectivity requirements
- Cost effective, easy to connect all assets
- Pervasive – wide and deep coverage
- Connect moving assets
- Replace aging PMR systems (Push-to-Talk)
- Support for lower power sensors

Wireless

1 wireless network for all critical applications
Current connectivity options are not sufficient for I4.0

LAN cables & other wired technologies

Challenged in economics, mobility, flexibility...

Current wireless technologies challenges

<table>
<thead>
<tr>
<th></th>
<th>L2TP</th>
<th>802.11ac</th>
<th>WirelessHART</th>
<th>Sigfox</th>
<th>LoRa</th>
<th>Bluetooth</th>
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<tbody>
<tr>
<td>Security</td>
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<td>Reliability</td>
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<tr>
<td>High data-rate / low latency</td>
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<td>Predictable performance</td>
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<td>Coverage</td>
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<td>LP-WAN</td>
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<td>Mobile</td>
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<td>Voice</td>
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</table>
Wi-Fi 6: better capacity, latency and data rate but still IT centric…

Private LTE/4.9G fit for OT applications requirements

**Wide and deep coverage**

- 4-100x coverage
- >3 extra walls of penetration

**Predictable performance**

- Stable <15ms latency
- 25x multi-user capacity

**Military grade security**

- LTE SIM authentication
- E2E encryption

**One network for all apps**

- Wi-Fi 5/6
  - Does not include IoT capabilities
- LTE integrates LPWAN
  - Narrow band, low power applications on same radio

**High speed mobility**

- Smooth handover up to 350kph
- Up to 15 sec latency on hand-over
Industrial-grade private wireless for secure, reliable & predictable performance

End-to-end solution from end-points to analytics and everything in between

Reach
Deploy wherever you need it
• Anywhere in the world
• Any site, any device
• On-premise and in the field

Flexibility
Use it & operate it as you see fit
• Fit for purpose modular or turnkey
• On-premise or cloud-based operations
• Owned or As-a-Service

Ease of use
Industries’ business is not networking but depends on it
• Plug-and-Play
• Web management portal
• Blueprinted solutions
• Managed operation
What’s new?
Latest additions to our comprehensive solutions
What's new?
Latest additions to our comprehensive solutions

Expanded reach & new markets

World 1st MulteFire modems (CPE) + LTE unlicensed (USB dongle & UE)
- Opening up the next big private wireless opportunity with high volume unlicensed LTE private networks for SME anywhere in the world.

Industrial terminal partner portfolio
- Device integration and customisation
- Devices from 18 suppliers

Enhanced

New small form-factor ruggedized field IP-MPLS over LTE routers
7705 SAR-Hmc
- More compact
- More spectrum bands support
- MPLS: QoS-assured, E2E encryption
- Temperature hardened (up to 65)
- Low power consumption
What's new?

Latest additions to our comprehensive solutions

Expanded reach & new markets

Vertical spectrum band support
Complementing existing large range of bands support including CBRS and MulteFire small cells
- B43 - Germany
- B28/38 - France
- B31/72 (450MHz) global
- B53 - Globalstar footprint

CBRS end-to-end solution readiness
- **End-to-end CBRS private wireless ready-to-go post ICD (12/19)**
- Nokia Private LTE CBRS OnGo solutions have been fully tested with multiple certified SAS solutions and involved in many of the current ICD
What’s new?
Latest additions to our comprehensive solutions

2nd generation enterprise core

CMU + EVC + GC - Enterprise optimized 5G ready packet & voice core
- **Compact, feature rich** based on latest generation cloud packet core
- **LTE/4.9G & 5G concurrent operation**
- Scalable from small campus to nationwide **Appliance or cloud based**
- CSP integration for connected campus
- **Native VoLTE** (client less UE voice communication) and all voice requirements (Group com, IP-PABX integration)

Increase flexibility

Wireless connectivity for Azure IoT
- Completing Microsoft Azure IoT Cloud and Edge offering with a full end-to-end private wireless connectivity solution
Enterprise Data and Voice Core
Most Advanced Feature Set in Smallest Footprint!

- CMU – Compact Mobility Unit for reliable and secure data connectivity in a private LTE/4.9G and 5G environment
- EVC – Enterprise Voice Core for Voice Services on the campus or rural areas with no coverage via a public network
- GC – Group Communication for MC-PTx (Mission Critical Push to Talk / Push to Video use cases and GIS – Geo Information Server for location/positioning services

Leveraging industry-leading Cloud Mobility Manager (CMM) and Cloud Mobile Gateway (CMG) deployed in 100 CSP customers

Leveraging market leading CSP VoLTE solution as an add-on module for enterprise networks

CMU
- HSS/PCRF
- MME
- S-/P-GW

EVC
- CSCF
- TAS
- SBC
- MRF

GC
- Control Room
- Recording Server
- PTT-Client/Server
- GIS-Server

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Private wireless main architecture options
MPW supports all architectural approaches for Enterprises & CSP private wireless offerings

Autonomous Private wireless
- On-premise full deployment
  - Managed by enterprise

Private wireless as-a-Service
- Hybrid cloud powered architecture
  - Managed by vendor or operator

Mobile operator core “Slicing”
- Hosted by mobile operator
  - Leveraging installed Cloud core and management
What’s new?
Latest additions to our comprehensive solutions

Enhanced capabilities

Enterprise tailored service suite
- Telecom Integration package
- Competence transfer
- Integrated Operations Center and vertical applications
- Legacy PTT integration services
- Network operations
- Consulting, design, deployment, migration

Private wireless labs
3x NAM, 2x European, 1x APAC labs
- Industrial applications and devices testing
- Integration staging
- Performance testing
- Over-the-air testing with vertical spectrum band on huge 3 sq.km campus

SpaceTime analytics & IoT
Turn data into actionable intelligence with AI based analytics that create concrete segment specific value
- Logistics hub optimization - Warehouses
- Asset lifecycle optimization - Power utilities
  - NEW: expansion to other segments
- Water events prediction – Rail
  - NEW: evolution to wider risk prevention
- Scene Analytics – Cross segments
  - NEW: object detection, vehicle analytics and BYOA
## Nokia Private wireless customers statistics

<table>
<thead>
<tr>
<th>Segment</th>
<th>Transportation</th>
<th>Energy</th>
<th>Public sector &amp; smart cities</th>
<th>Manufacturing</th>
<th>Industries other</th>
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<tbody>
<tr>
<td>Region</td>
<td></td>
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<td>NAM</td>
<td>27%</td>
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<tr>
<td>LATAM</td>
<td>9%</td>
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<td>Europe</td>
<td>36%</td>
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<td>APAC</td>
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<td>MEA</td>
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<td>Channel</td>
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<td>Direct</td>
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<td>Indirect</td>
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<td>51%</td>
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<td></td>
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<td>49%</td>
</tr>
</tbody>
</table>
Vertical critical connectivity needs Private & Public networks

<table>
<thead>
<tr>
<th>Critical connectivity need category</th>
<th>Industrial Sites, Campuses</th>
<th>Connected Sites, FAN, Regional</th>
<th>Nationwide</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transport &amp; Logistics</strong></td>
<td>Airports Factories</td>
<td>Smart cities</td>
<td></td>
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<tr>
<td><strong>Energy</strong></td>
<td>Ports / Ships</td>
<td>Warehouses</td>
<td>Delivery trucks</td>
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<tr>
<td><strong>Rail</strong></td>
<td>Power gen, Sub-stations Oil &amp; Gas, Mines</td>
<td>Grid, pipelines</td>
<td>Field repair staff and assets</td>
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<tr>
<td><strong>Public Sector</strong></td>
<td>Urban rail</td>
<td>Mainline rail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GDBI, Rural</td>
<td>PS deployable</td>
<td>Public Safety Defence</td>
</tr>
</tbody>
</table>

**Private wireless networks** gives enterprises their own dedicated wireless network for their operational needs.

**Shared public network slices**, leverage CSP networks to guarantee SLA of enterprise assets in wider areas.
From now to next

Bringing the most complete 5G ready industrial wireless solutions that meets industrial connectivity application requirements for Industry 4.0 today and tomorrow
Industry 4.0: The time is now

History of LTE connected industrial ecosystem

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2015</td>
<td>1st pLTE mine</td>
</tr>
<tr>
<td>2015</td>
<td>Mine testing complete</td>
</tr>
<tr>
<td>2016</td>
<td>pLTE installation in Komatsu test mine</td>
</tr>
<tr>
<td>2017</td>
<td>pLTE validated for AHL</td>
</tr>
<tr>
<td>2018</td>
<td>1st LTE ready trucks</td>
</tr>
</tbody>
</table>

Realistic 5G industrial ecosystem timeframe

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
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</tr>
<tr>
<td>2018</td>
<td>1st LTE ready trucks</td>
</tr>
<tr>
<td>2019</td>
<td>1st industry capable chipsets</td>
</tr>
<tr>
<td>2020</td>
<td>Start of 5G R16 capable ecosystem</td>
</tr>
<tr>
<td>2021</td>
<td>Start of 5G R17 capable ecosystem</td>
</tr>
<tr>
<td>2022</td>
<td>Start of 5G R18 capable ecosystem</td>
</tr>
<tr>
<td>2023</td>
<td>All vertical features</td>
</tr>
</tbody>
</table>

Private LTE/4.9G in operation til 2030, supporting existing assets & LPWAN devices

- 5G R15 SA / R16 private wireless industrial PoC
- 5G radios added to existing 4.9G private wireless networks and 5G R16 greenfield
- Greenfield all features 5G only industrial private wireless

2-4 years from start to 1st commercial LTE industrial ecosystem
Delivering many industry requirements with 4.9G TODAY

Utility

- Grid monitoring to prevent illegal tapping and increase grid reliability
- Grid automation for maintaining quality

Regional private wireless network coverage (5% coverage from CSP network)
- 78,000 smart meters
- 1,300 load balancers
- 850 concentrators

Mining

- PMR replacement for voice communications
- Improve worker safety with smart garments
- Future automation solutions (AHS)

Mining site coverage utilizing Telefonica core slice
- IP-MPLS over private LTE for enhanced reliability

Peru, World 9th biggest copper mine.

Airport

- Gates and airside operational efficiency for below-wing process (faster plane turn-around)
- Airside coverage for vehicles connectivity

Austria, 24M passenger per year.

Autonomous private wireless, with triple back up from A1 core
- % of private network also used for A1 subscriber capacity boost
- Triple core redundancy

Port

- Port digitalization
- One wireless network to replace all legacy networks and to support all operational applications

Finland, 9th & 10th container port wins.

Hybrid edge cloud as-a-service private wireless via Ukkoverkot
- IT driven operation, looking for fast deployment and private wireless benefits without the complexity

Brazil, World largest wind generator

© 2019 Nokia
Providing choice to suit all requirements

Variety of needs that generally breaks into 2 categories

Focus on simplicity

Digital Automation Cloud (DAC)
- Integrated **Plug&Play as-a-service** solution
- Digitalization/automation platform with ready-to-run applications
- Enterprises & partners

Need for full control

Modular Private Wireless (MPW)
- End-to-end customizable solution for most **demanding enterprise requirements**
- Enterprises & partners
- CSP private wireless offering

- Latest generation LTE: 4.9G and smooth 5G evolution
- Leading small cell portfolio & cloud core
- Largest range of spectrum options
- Complete **IP-MPLS and optical transport** solutions
- End-to-end Management and orchestration

**Complementary solutions**

**WING** Worldwide IoT Network Grid

**Services** Deploy, Managed services, Integrated operation centers

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Nokia industrial-grade private wireless
Helping industry accelerate their Industry 4.0 transformation

Enterprise requires
• Solution approach
• Richness in offers and capabilities
• Richness in coverage
• Richness in go-to-market options

Nokia’s approach

Unmatched end-to-end capability
Private wireless is more than radio and core

Unmatched expertise
Deep segment practice & service offering

Trust and global reach
120+ customers in all markets, all segments

Flexible range of solutions
Easy to deploy bespoke

Broad partnerships
CSP, Cloud, Industrial, SI & Consulting

Laser focused on industrial automation
Focused R&D and investment