5G
Private Wireless Networks

28as Palestras sobre
Comunicações Móveis

IST

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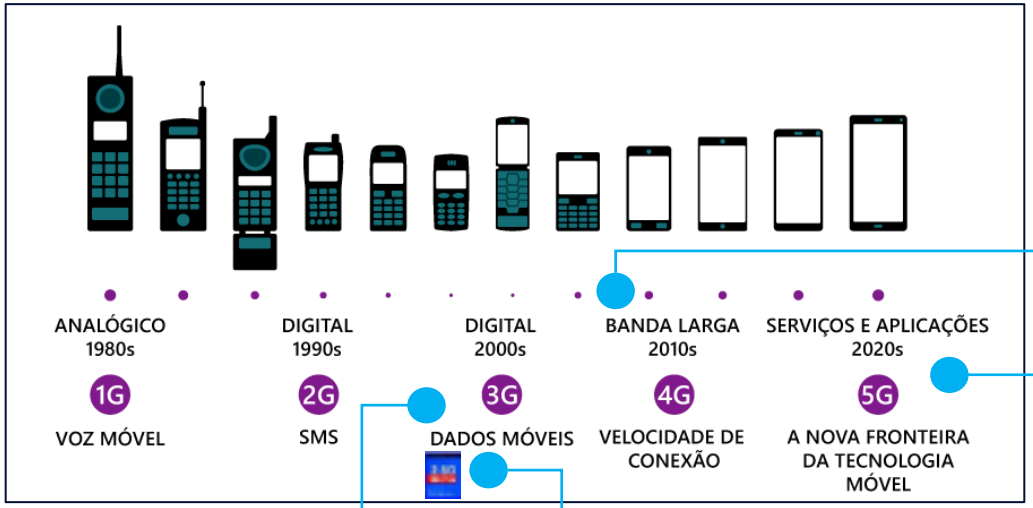
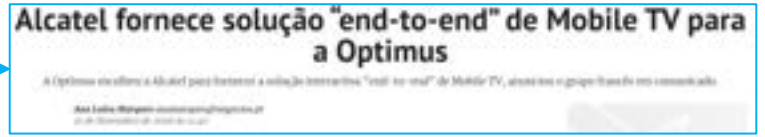
Evolution of mobile networks in Portugal



Source: Portal 5G (ANACOM)

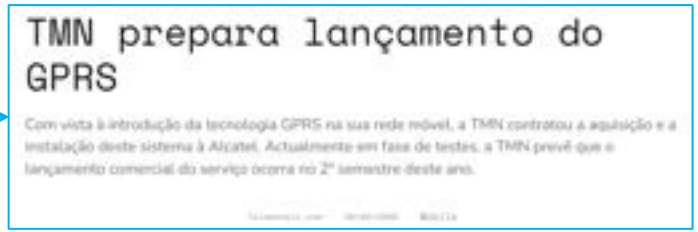

Alcatel fornece solução "end-to-end" de Mobile TV para a Optimus


Nokia cria novo centro de investigação para 5G e 6G e abre 100 vagas em Portugal

Está em causa um polo tecnológico para as redes móveis 5G e 6G, localizado na Amadora, com a operação portuguesa a prever o recrutamento de mais cem profissionais até ao final de 2024.

LEIC98

DEI

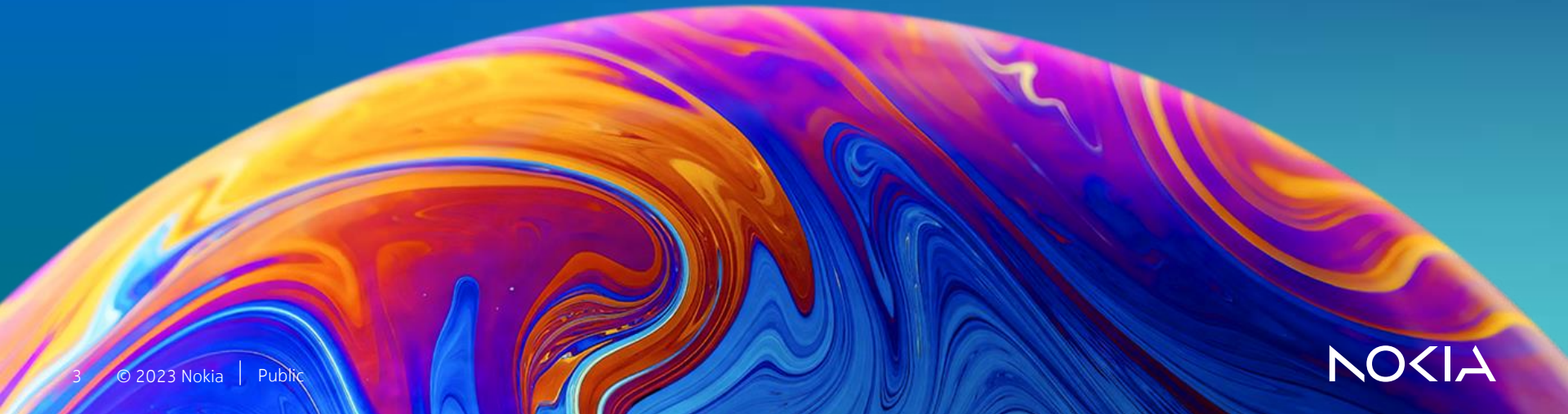

TMN prepara lançamento do GPRS

Com vista à introdução da tecnologia GPRS na sua rede móvel, a TMN contratou a aquisição e a instalação deste sistema à Alcatel. Actualmente em fase de testes, a TMN prevê que o lançamento comercial do serviço ocorra no 2º semestre deste ano.

At Nokia, we create technology that helps the world act together

When the world's people, machines and devices are in sync with each other, we can realize the full potential of digital:

- Sustainable business growth
- Productivity in industry
- Inclusive digital access



Creating new opportunity with customers

Service providers

Going beyond telecommunications

7bn+
Subscriptions supported by our mobile networks

500m+
Fixed broadband lines and ports shipped

Enterprise and government

Accelerating digital transformation

2.2k
Mission-critical customers

560+
Private wireless customers

Webscalers

Delivering the next generation of cloud

135%
YoY growth of our webscaler business

7
Partnerships and engagement with 7 critical hyperscalers

Technology licensees

Adopting cutting-edge technology

20k+
Patent families

4.5k+
Patent families declared essential to 5G

Industry 4.0

Industry 4.0, also known as the **fourth industrial revolution**, enables enterprises, governments and public sector agencies to use **innovative digital technologies, smart automation and advanced analytics to transform their operating processes**.

Digitalization	Understand and control physical assets to gain better business outcomes such as efficiency, productivity & safety.
Resilience	Maintain business continuity, through shifts in market or environmental conditions.
Sustainability	Help achieve both business and environmental goals ***"There is no green without digital"***

Industry 4.0 will deliver massive increase in productivity & economic value creation

Enhance efficiency
with process automation

Increase agility
to meet fast changing requirements

Better decision
making via intelligent insights

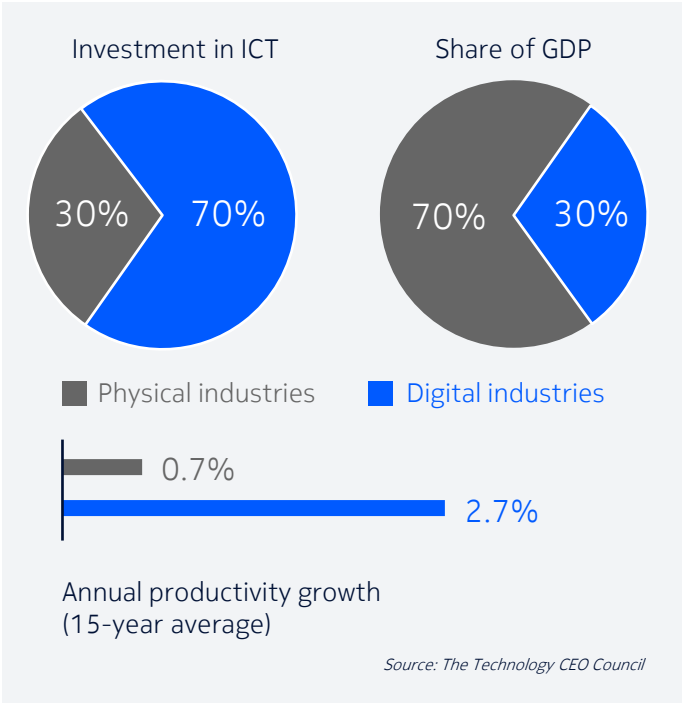
Increase worker safety & productivity

Sustainability
efficiency helps lower environmental impact

...all this while maintaining asset heavy industries "Must-have" needs

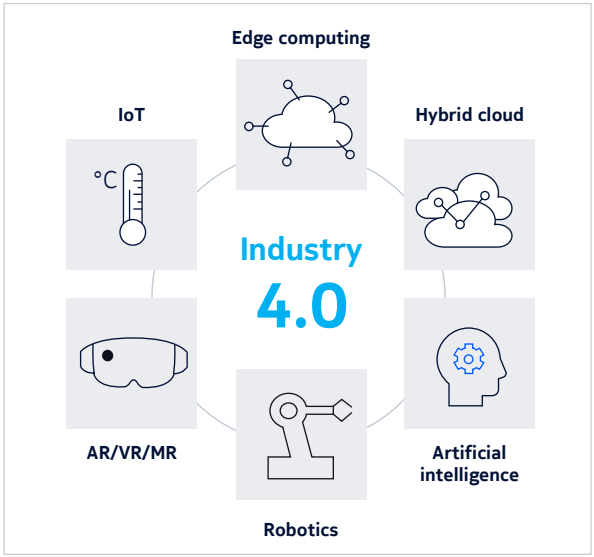
Continuous operation **Safety** **Security**

On the cusp of the 4th industrial revolution



...and this is happening NOW

Confluence of key technologies enablers create the perfect environment for **Industry 4.0**



Current connectivity options are not sufficient for I4.0

LAN cables & other wired technologies

Challenged in economics, mobility, flexibility…

Current wireless technologies challenges

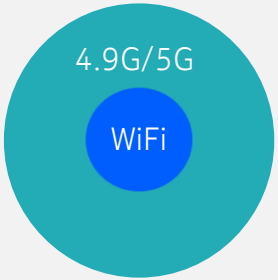
Expectations	P25 TETRA	Wi Fi 802.11ac	WirelessHART	sigfox LoRa	Bluetooth
Security	■		■	■	
Reliability	■				
High data-rate / low latency		■	■		
Predictable performance	■		■		
Coverage				■	
LP-WAN			■	■	■
Mobile	■				
Voice	■		■		

Wi-Fi 6: better capacity, latency and data rate but still IT centric…

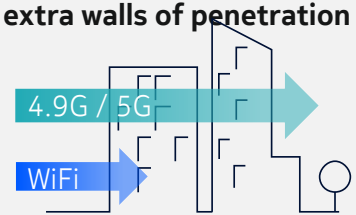
Private 4G/5G fit for OT applications requirements

Wide and deep coverage

4-100x coverage



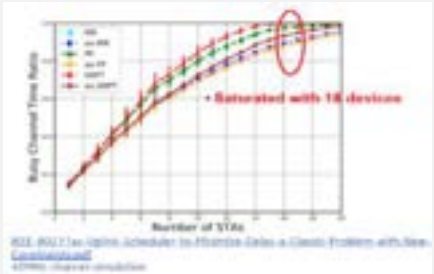
>3 extra walls of penetration



Predictable performance

Stable <15ms latency

25x multi-user capacity



Military grade security

Wi-Fi
WPA2/3 compromised

4.9G/5G
SIM authentication
E2E encryption

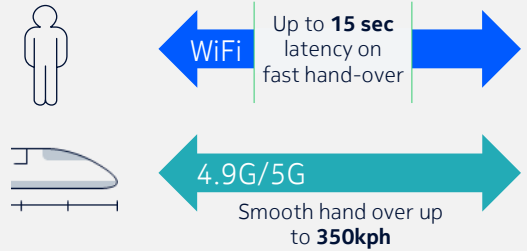
One network for all apps

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

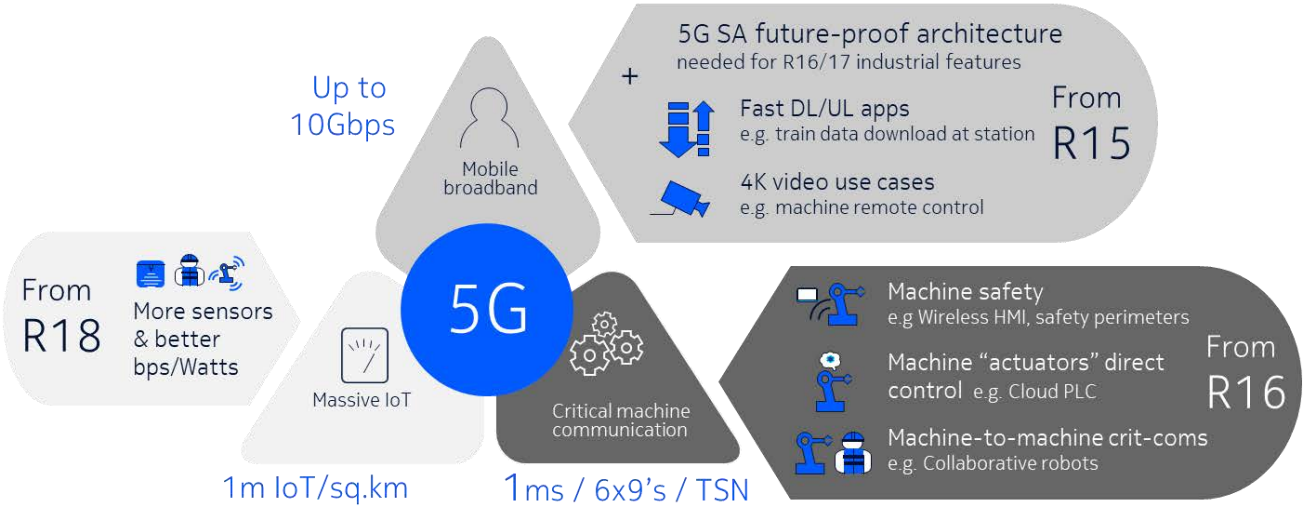


5G for Industry 4.0: The time is now

All stars align (spectrum, ecosystem, solutions) to start NOW

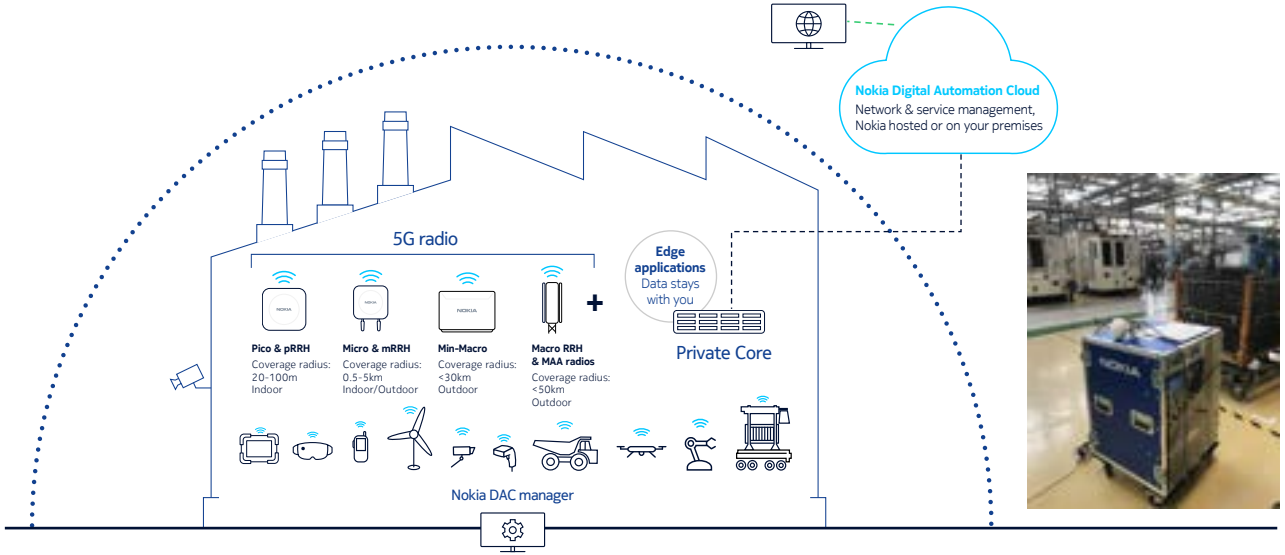
Reliable wireless connectivity is critical for **digitalization**

Capabilities and industrial use case enabled by 5G



Nokia Private Wireless Network

Dedicated connectivity & processing power for critical use cases



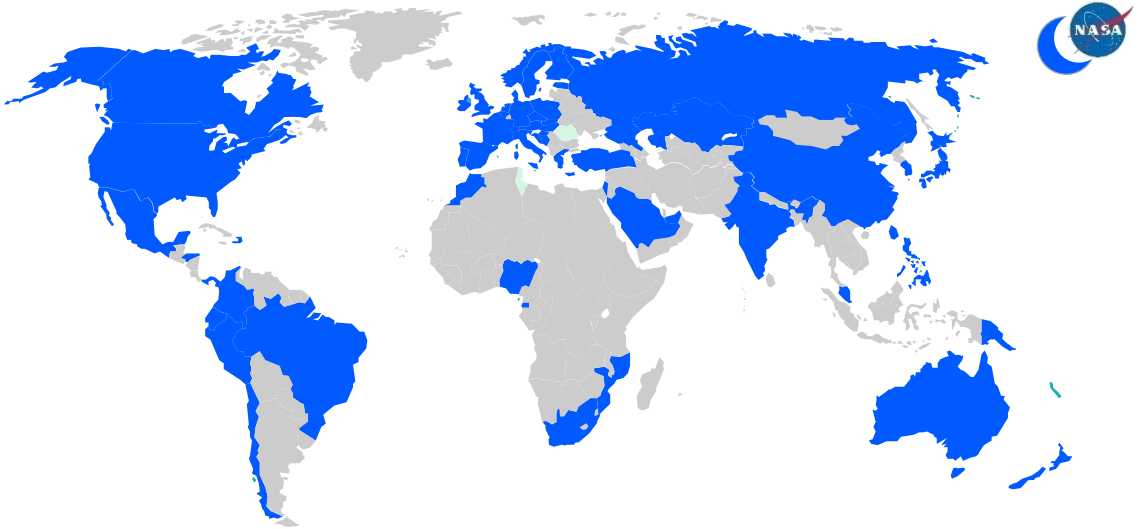
Private wireless connectivity
5G for enterprises' OT critical use cases with tailored coverage & dedicated capacity to reliably and securely connect industrial assets (machines, sensors, tools, etc.) and workers

On-premise Edge
Dedicated local processing capability to treat critical OT use cases real data securely, reliably and with low latency

- 3GPP standardized
- A single wireless network for all critical applications
- Scalable
- Autonomous
- Secure by design
- With reliability and data confidentiality
- Compact and easy to deploy

560+ private wireless customers

Market leadership and innovation



Public references

Recent new logos

ALCATEL SUBMARINE NETWORKS

mtc Manufacturing Technology Centre

sti

HOLMEN IGGESUND

MEXT · NHS South London and Maudsley · flex · Antamina · Köllitsch · Sächsen · Western Power Distribution · digital c · Estonian Cyber Range THINNECT · Posiva · SIEMENS · AIMS · AGNICO EAGLE · 5G Playground Carinthia · equinor · BASF · arcelik · CODELCO · TOYOTA · GRAZ · KUKA · UEC · ABP · ASSOCIATED BRITISH PORTS · SALZBURG AG · WISTA · VALE · Technische Universität Kaiserslautern · Kyutech · Port of Seattle · ELEKTRO · brussels airport · UTS · NIPPON STEEL · CIMCON · NORCAT · SAAB · Société du Grand Paris · Infrastructure Networks · DOS PALOS ORO LOMA JOINT UNIFIED SCHOOL DISTRICT · butachimie · VIE · EWA · MAGNA · ncrtc · PORT OF KOKKOLA · CARGOTEC · beach · UBI · Home Office · RHODE&SCHWARZ · Ameren · conectar4GRO · LUT University · accenture · CITY OF TAMPERE · Etteplan · FINAVIA · 450connect · SANDVIK · KKnetwork · ALTAN · STEVECO · OMRON · BritishSugar

Why the industry is asking for private wireless networks

Automated falling conductor disconnect to avoid fire

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

Wind turbine monitoring for predictive maintenance

FAN convergence and automation

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

Drivers' **tiredness monitoring**

Increase safety with remote drilling

Introduce **wall-slope and environment sensors**

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

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

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

Real-time **work order system** for cranes and AGV 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 and reliability issues**

Digital twin **machine connectivity**

Workers' **connected tools and safety**

"Lot-size one" manufacturing

Enhanced Group Communications including push-to-video and geo mapping

Better situational awareness with real time video from drones, vehicles and body cameras

First responders' **bio-vital signs monitoring**

INDUSTRIAL-GRADE CONNECTIVITY

Aviation use case examples

Enabled by Private Wireless

brussels airport
the heart of Europe

- High-performance and reliable connectivity for
  - Airside operations
  - MRO 4.0 (Remote Visual Inspection; Remote Expert Support)

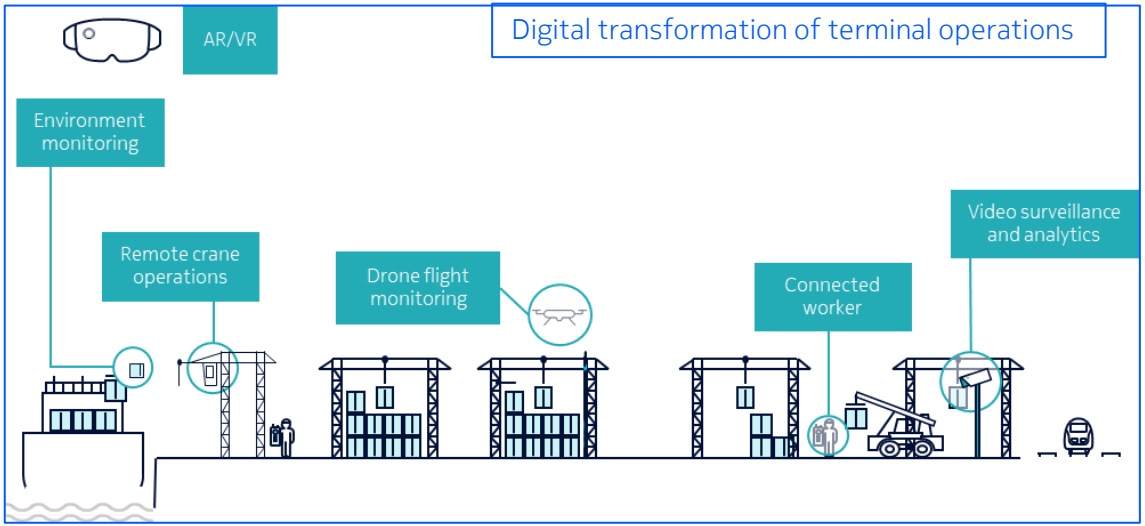
Lufthansa Technik

NOKIA

Maritime use case examples

Enabled by Private Wireless

- Wireless data for manned operations
- Wireless remote control for (semi-) automated operations
- Voice Communications
- Remote reefer monitoring
- Predictive asset maintenance
- Drone inspection
- Worker's fatigue and safety monitoring

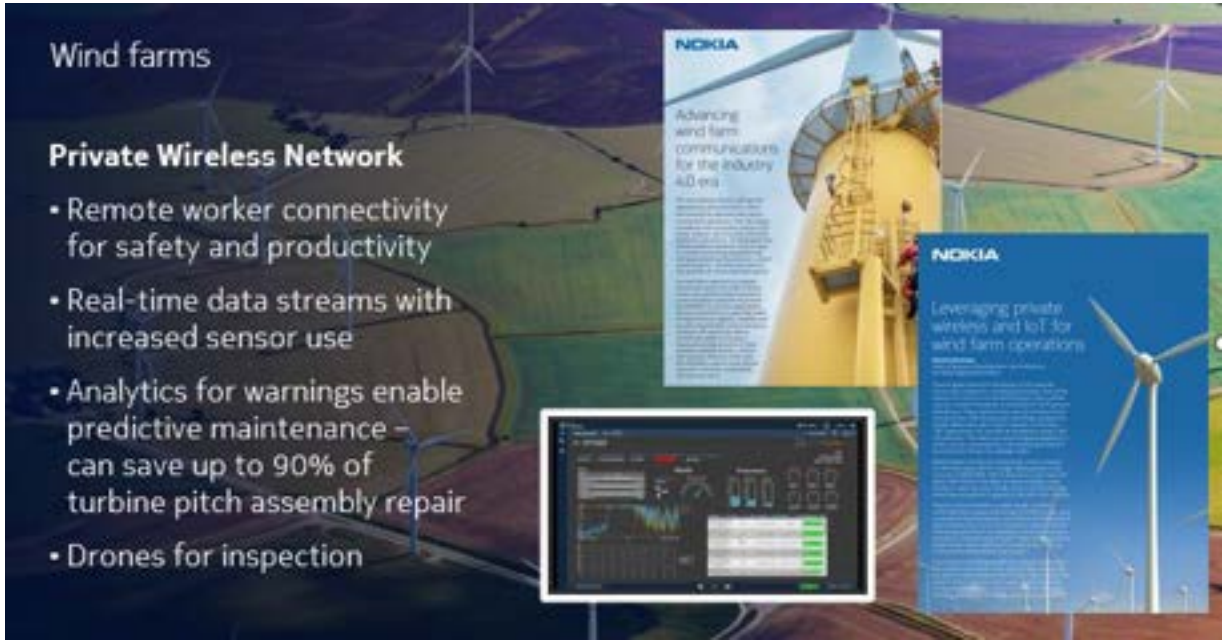


Energy use case examples

Enabled by Private Wireless

Energy

- Automate falling conductor disconnect to avoid fire
- Maintain grid reliability with growing distributed renewables/storage
- Monitor wind turbines for predictive maintenance



Mining use case examples

Enabled by Private Wireless

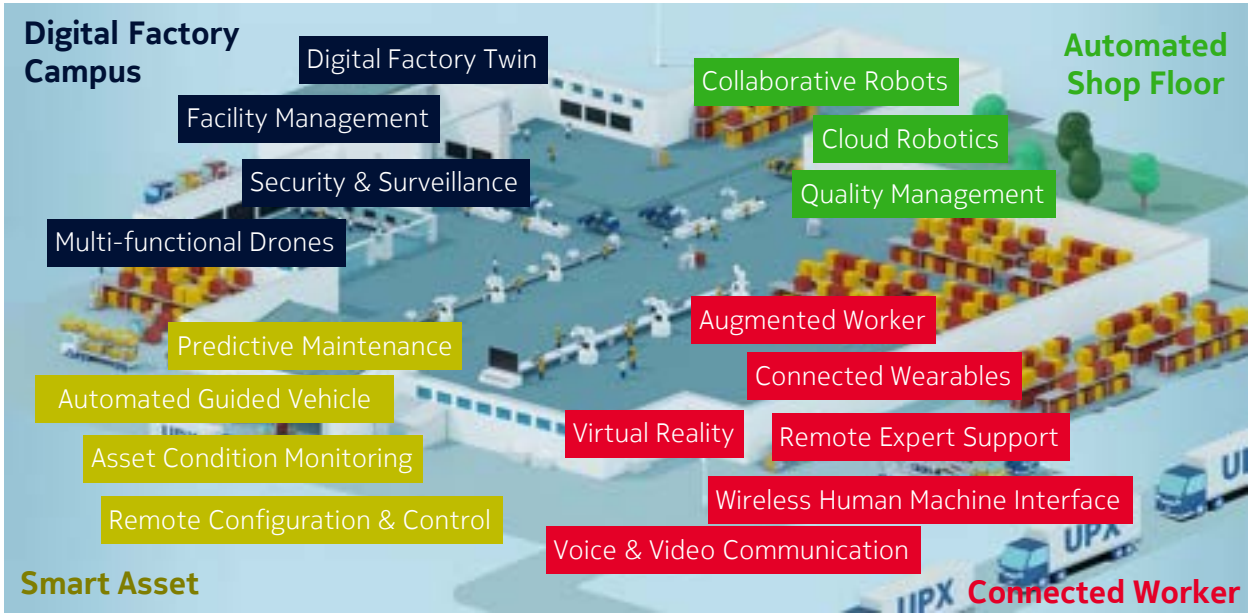
- Increase safety by monitoring driver fatigue and enable remote drilling
- Increase business efficiency with Push-to-X communication
- Introduce wall-slope and environment sensors analytics
- Real time work orders

CONNECTED DIGITAL MINE

Manufacturing & Logistics use case examples

Enabled by Private Wireless

- Camera based visual quality inspection
- Help enhance AGV operation and efficiency
- Improve worker efficiency with real time contextual data
- Running virtual PLC for improved machines coordination

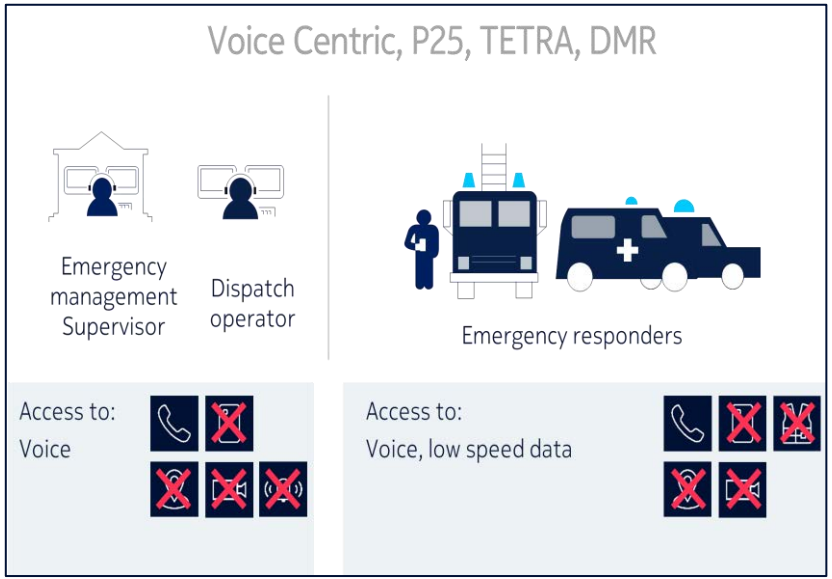



WHAT ABOUT
PUBLIC SAFETY?
NOKIA

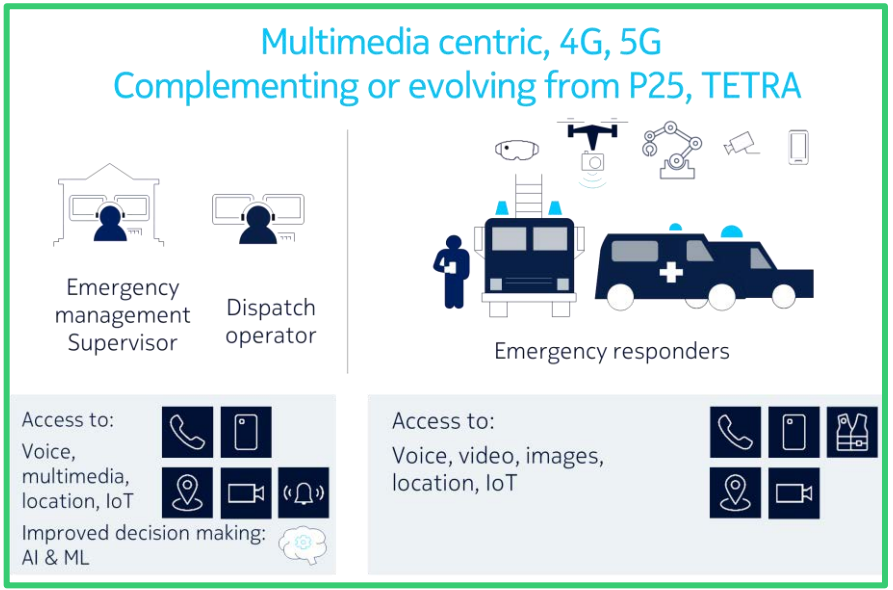
Public Safety Mobile Broadband

Addressing the gap

From ....



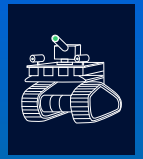
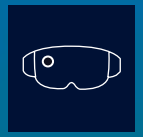
To ....



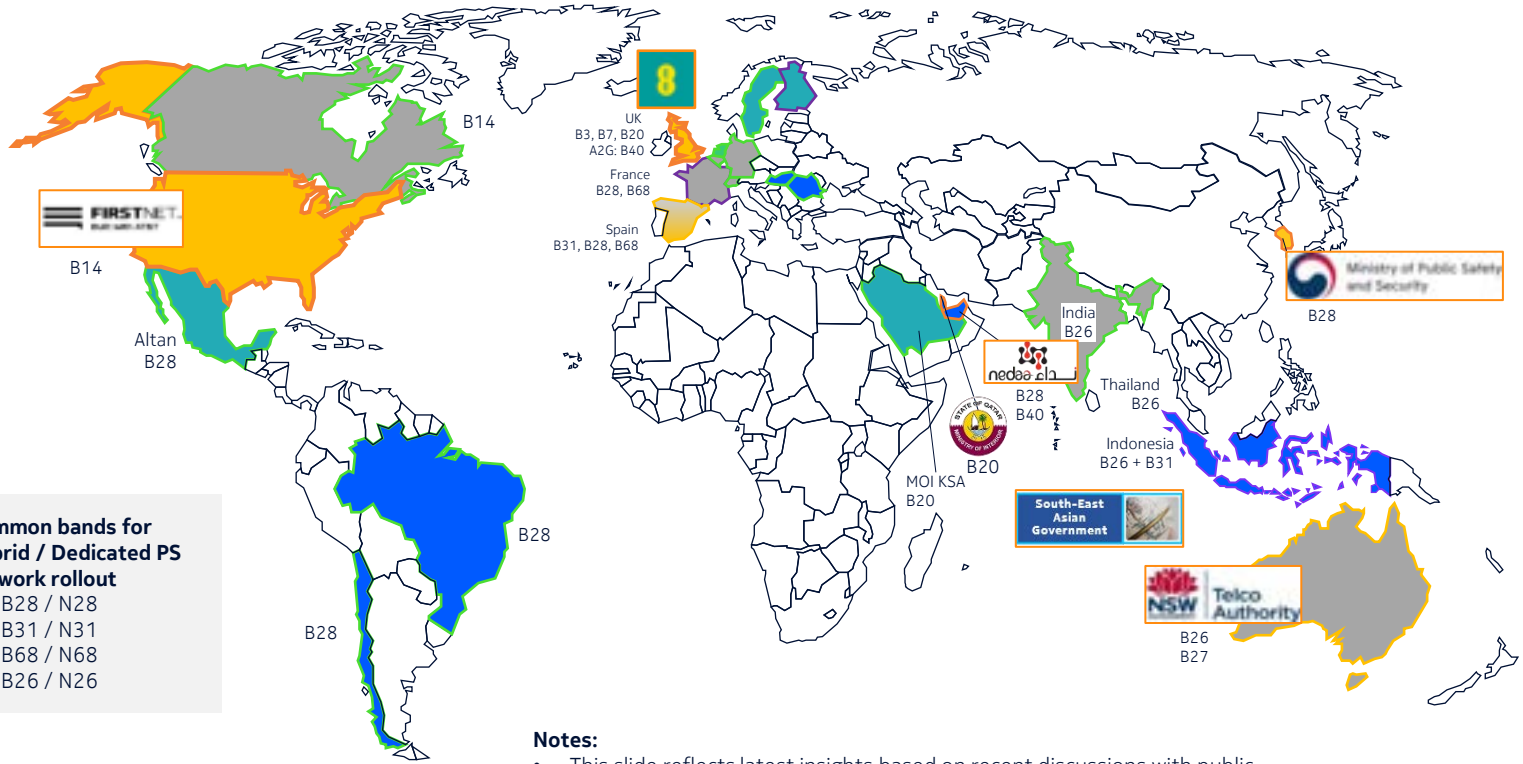
New, multimedia based actionable information leading to **saving more lives**

Public Safety use cases

How 4G/5G improves saving lives

		4G	2020	5G PHASE 1 (Broadband / Hotspot)	2023	5G NEXT PHASES (Low latency, Slicing)
	Improving Situational Awareness	• Cameras on drones • Officers with bodycams • Evidence photo's • Vehicle cameras		• Increased camera density • Improved image quality • On demand surveillance for special events		
	Improving intervention safety	Remote controlled • Drones • Robots • Assisted driving				• Autonomous vehicles for intervention in hostile environment • Controlled swarm of Drones
	Faster treatments	• Remote diagnostics		• Enhanced connected tools (e.g. scanners) for remote diagnostics		• Remote (robotic) controlled surgery (haptic feedback)
	Improving Situational Awareness	• Augmented reality; non real-time sensitive for intervention assistance				• Real-time augmented reality content overlay (e.g face recognition in crowd,…)
	Internet of [Life Saving] things	• Connected wearables				• Massive number of connected objects and sensors

Global status of Mobile Broadband for public safety



Common bands for Hybrid / Dedicated PS network rollout

- B28 / N28
- B31 / N31
- B68 / N68
- B26 / N26

Rollout Strategy

- MNO
- S-MVNO
- Hybrid
- Dedicated

Status

- In operation
- POC
- Model Planned but still under discussion
- Model decided, not in operation yet

Notes:

- This slide reflects latest insights based on recent discussions with public safety operators; deployment strategies may change over time.
- Logos on map show Nokia broadband references with public safety entities

Public Safety mission-critical mobile broadband

Deployment options

	Radio Access Network	Core Network	Public Safety Apps	Public Safety Customer Care	Pros	Cons	Architecture	Ownership
	Public Safety Operator							Dedicated PS Core ■ Part of dedicated PS Core ◪ Dedicated PS RAN ● (Shared) RAN ◔
	MNO Commercial networks							
1	Deployables			**MNO**	• Benefits from MNO spectrum • Fast time-to-market	• No control over subs • No control over coverage • No traffic separation	MOCN	MNO: ■ ◔ PS Operator:
2	Deployables			**S-MVNO**	• Tight control over subscriber management, QoS, prioritization and apps	• No control over coverage	MOCN	MNO: ◪ ◔ PS Operator: ◪
3	Deployables			**Hybrid**	• Extends coverage at critical hot spots	• Increases complexity of network management	MOCN	MNO: ◪ ◔ PS Operator: ◪ ●
4	Deployables			**Dedicated**	• Provides full autonomy to the public safety agency	• Need for spectrum • Expensive	Dedicated	MNO: PS Operator: ■ ●

Network Evolution Requirements

COVERAGE

Ubiquitous coverage

- National: S-MVNO or Dedicated Network
- Add own sites to cover white zones + extra capacity (Hybrid)
- Deployables
- Air to Ground (A2G)

RESILIENCE

No single point of failure

- Resilient architecture
- Site hardening (power, fencing…)
- Cyber resilience

PERFORMANCE

Optimal performance

- Access Control
- Admission Control
- Traffic Prioritization (QCI)
- Traffic Optimization

CAPABILITIES

Provide best service to public

- MCx services
- Location based services
- PMR / Mobile Broadband interoperability

Who we are today

A B2B technology innovation leader, realizing the potential of digital in every industry

Our brand promises

- Future-ready performance
- Impact at scale
- Collaborative advantage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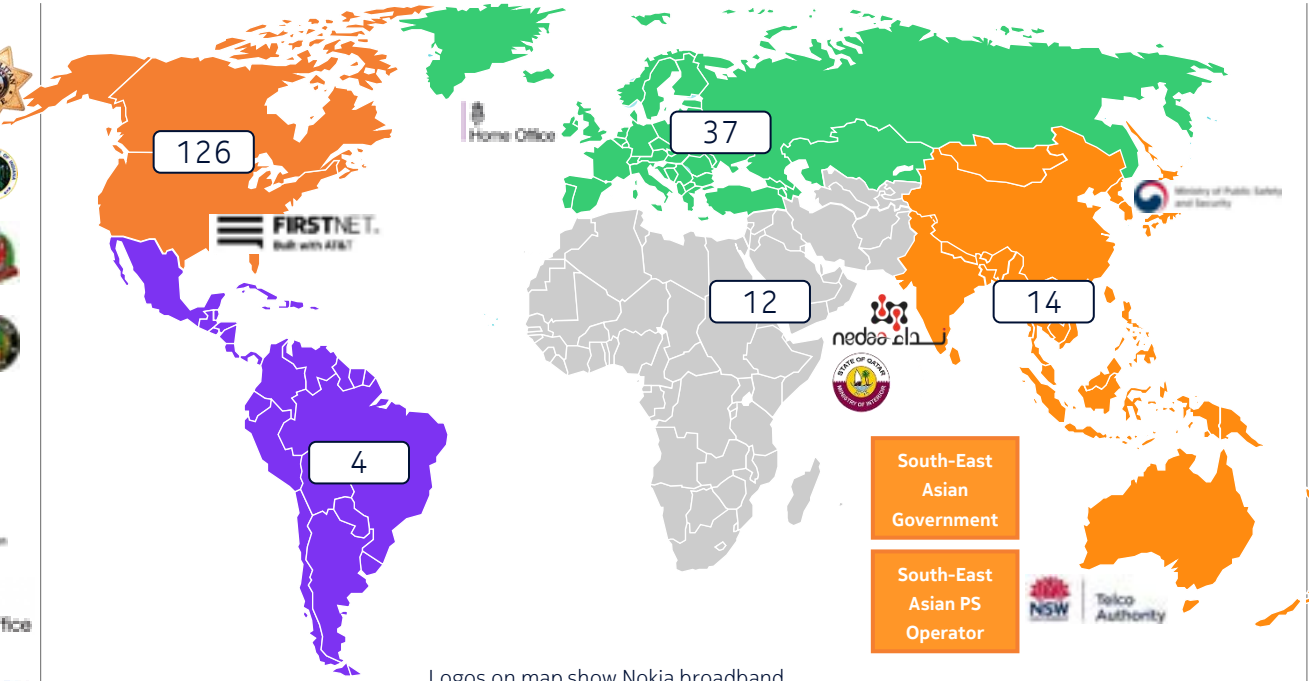
Nokia Public Safety projects

>190 mission critical public safety Projects

LOGO's



Logos on map show Nokia broadband references with public safety entities

MEMBERSHIP

TCCA

SOLUTIONS

- **WAN Mobile Broadband**
- **Group Communication**
- **Air to Ground Broadband**
- **Transport**
- **Public Warning System**
- **CAMPUS private Wireless**
- **Next Gen Emergency Service**
- **Cyber Security**
- **Deployables**
- **Managed Services**

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Public Safety Mobile Broadband (PSMB) Proof of Concept, NSW Australia

World 1st public safety 4G Secure MVNO with 2 different CSPs

"This is a major step forward towards delivering a faster and smarter national capability for our emergency services to fuse critical information, make informed decisions quickly, and act on those decisions with confidence."

David Littleproud - Minister for Agriculture, Drought and Emergency Management

Read the PR

Challenges

- Major bushfires endangering Australian citizens and first responders
- Aligning critical communication between police, fire brigades and ambulances.
- Improving situational awareness by proving reliable broadband communication and smart applications across the whole Australian territory.

Solution

- All Australian jurisdictions have agreed to participate to the development of a national PSMB network
- Take advantage of existing MNO's Radio access networks, through an MVNO deployment model connected to 2 different CSPs.
- Start with a Proof of Concept that aims to test the delivery models.
- Nokia to provide 5G ready core network for the Public Safety agencies, MCPTT and interworking gateway with legacy P25 system

Benefits

- Better situational awareness and aligning the communication between all jurisdictions will lead to better informed decision making.
- Enhanced coverage and reliability thanks to connection to 2 different CSPs and interworking with P25
- PoC results will drive the requirements for a National Public Safety Mobile Broadband Network
- Future-proof solution as public safety core network is 5G-ready.

Ministry of Public Safety and Security (MPSS), Korea

Dedicated and nationwide Public Safety

Ministry of Public Safety and Security

SK telecom

Read the press release

Challenges

- Difficulties to interact and communicate in real time among government entities
- Limitations due to heterogeneous technologies and systems
- Existing digital Tetra network and analog VHS network couldn't offer video or data capabilities for enhancing situational awareness of first responders
- Reducing the risk of over dependency on supplier

Solution

- Dedicated LTE public safety network for:
  - Pyeongchang city in KT area
  - Gangneung, Jungsun cities in SKT area
- Dedicated spectrum allocation for safety: 2x10 MHz 3GPP Band 28 (APT-700)

Benefits

- Test and validation of basic PS-LTE functionalities
- Improve standard operational procedures among government orgs, when LTE dedicated network introduced.
- Interworking policies agreed with MOLIT (Ministry of Land Infra & Transport) and MOF (Ministry of Oceans & Fisheries).
- Encourage local industries to develop PS-LTE related solutions (applications, devices)

NOKIA

Needa (government security network operator), Dubai

Next generation network for mission critical and smart city services

Yousif Al Ali, Chief Technical Officer, Nedaa, said: “Dubai has historically pioneered in providing exceptional quality of life, and an unparalleled business and technology innovation environment, Nokia has been an integral part of Dubai’s security communications network since 2001, and the company’s eagerness to adapt to our new, stringent security requirements gives us the confidence to make our city the safest and smartest in the world.”

Challenges

- Increasing safety and security in the city
- Developping the reliable platform for the support of IoT and smart applications evolution
- Applying next generation mission critical and IoT technologies for areas including emergency services support, e-government, transportation and healthcare.

Solution

Next-generation e2e mission-critical communications network including:

- Comprehensive security solutions, core and LTE radio access
- IP/MPLS, optical and microwave backhaul
- Professional services

Benefits

- Creating a safe and smart city for residents and visitors with:
  - Future-proof, 5G-ready solution
  - Shared services for all governmental departments
- Enabling mission critical and IoT use cases with the same technology infrastructure

Ministry of Interior, Qatar

The first public safety entity to award a public-safety LTE network contract in the Middle East

Watch the video

Challenges

- Existing Tetra network unable to provide broadband services
- adding public safety LTE to existing Tetra services and ensuring the coexistence of the two systems
- Supporting broadband and voice services as well as new innovative applications for increasing situational awareness and operations efficiency

Solution

- Dedicated LTE network based on Band 800 MHz with 10 MHz spectrum including:
  - Virtualized packet core
  - IMS/VoLTE
  - Nectact
- Commercial LTE network in operation since 2012:
- First phase with 24 sites in Doha in 2012
- Second phase: more than 80 connected sites

Benefits

- First private FDD-LTE network for Public Safety in the world
- Enabling wide range of public safety broadband applications such as multimedia and transmissions from incident locations to the ministry's command center.
- From 2015 onwards Push-to-talk services with ruggedized devices and tablets were added.
- Complement the existing TETRA network

Emergency Services Network (ESN), UK

The world's first FDD-LTE public safety over commercial network for emergency services (police, fire & rescue, ambulance, etc.)

Challenges

- Existing Tetra network unable to provide Broadband services
- To replace Tetra network with high-bandwidth public safety communications at a lower cost.
- To support broadband and voice services as well as new innovative applications for public safety community
- ESN addresses 300 000 first responders, 50 000 vehicles, 115 aircraft and 200 control rooms

Solution

- Shared LTE network based on commercial LTE operating in 800 / 1800 /2600 MHz bands
- Additional coverage extensions of 800 MHz band for geographic coverage added when contract was awarded. Deployment started in 2016
- Public safety SW features such a QoS differentiation & prioritization
- AVA Big Data analytics for rapid coverage KPI validation

Benefits

- In shared commercial network, prioritisation of users and services for enhanced power and transmission resiliency requirements
- Higher coverage requirements as per ESN needs
- Enabling wide range of Public Safety broadband applications.
- Ability to introduce Air to Ground and in-vehicle devices/solution.

Air to ground communications, in the UK

The world's first air-to-ground mission-critical LTE network for emergency services

"We're thrilled to partner with Nokia to build a first-in-class and ground-breaking 4G Air-to-Ground network for emergency services across the UK'

Richard Harrap, Managing Director ESN at EE

Read the press release

Challenges

- New mobile broadband network for public safety agencies is not properly covering aircraft from these agencies
- Many of these aircraft are used during operations either alone or in coordination with field teams, and need to benefit from the new data centric services.

Solution

- TDD LTE based network in 2.3 GHz band deployed to provide Air to ground coverage, based on Airscale radio.
- Cell size of 70+ km.
- Coverage up tp 10000+ ft altitude and for aircraft flying up to 300+ km/h speed
- Handover with terrestrial network spported.

Benefits

- Aircrafts can now also benefit from data based public safety communications to enhance their operations.
- Tighter integration/Collaboration of aircraft with teams operating in the field

FirstNet, USA through the Service Provider ATT

FIRSTNET™ Built with AT&T

AT&T Selected by FirstNet to Build and Manage America's First Nationwide Public Safety Broadband Network Dedicated to First Responders (March 30, 2017)

Challenges

- US First Responders need a Secure , reliable and resilient Broadband Mobile connectivity
- First Responders need an interoperable mobile communication across states, counties and across multiple agencies

Solution

- create a nationwide seamless, IP-based, high-speed mobile communications network based on LTE Band 14: in addition the network will
  - Better connect first responders to the critical information they need in an emergency
  - Further the development of public safety focused IoT and Smart City solutions
  - Enable advanced capabilities, like wearable sensors and cameras for police and firefighters, and camera-equipped drones and robots that can deliver near real-time images of events

Benefits

- Today is a landmark day for public safety across the Nation and shows the incredible progress we can make through public-private partnerships," said U.S. Department of Commerce Secretary Wilbur Ross. "FirstNet is a critical infrastructure project that will give our first responders the communications tools they need to keep America safe and secure.
- Nokia is a vendor of ATT for the Band 14 specific Public Safety spectrum solution that will be rolled out in the network

NOKIA

Southeast Asia government

Nokia selected as the vendor of choice to roll-out a nationwide Defense and public safety LTE network in a leading country in Southeast Asia

Challenges

- Existing network unable to provide Broadband services.
- Complement existing voice centric network with high-bandwidth mission-critical public safety network.
- To support broadband and voice services as well as new innovative applications for the public safety community

Solution

- Dedicated LTE network based on:
- Airscale radio platform.
- Telco cloud core
- Security gateway and NetGuard solution for network cybersecurity.
- Nokia Network management system
- eMBMS for communications broadcast
- Mission-critical PTT
- Nokia LTE deployables

Benefits

- The new network is enabling wide range of data centric Public Safety broadband applications.

Nokia One Digital Platform for Industrial Transformation

Helping enterprises accelerate their Industry 4.0 journey

Enterprise OT requires

- Solution approach that addresses
  - Pervasive reliable wireless connectivity needs
  - On-premise OT use case data processing requirements
  - Interface with south-bound, north-bound & cloud systems
  - Powerful, future proof, yet easy to use
- Experience of their specific segments & related use cases
- Richness in go-to-market options

Nokia's approach

Unmatched end-to-end capability

Private wireless combined with OT edge for full digitalization capabilities

Unmatched vertical expertise

Deep industrial experience, segment practice & segment blueprints

Flexible range of solutions

Two private wireless solutions, 1st off-the shelf OT Edge with ecosystem neutral application approach & industrial devices

Broad partnerships

CSP, Global System Integrator, Cloud, specialized SI, VAR & Consulting

Trust and global reach

560+ customers in all markets, all segments

Laser focused on industrial automation

Focused R&D and investment


NOKIA