

# Mobile Networks progress update



Pekka Lundmark  
President and CEO

Tommi Uitto  
President of Mobile Networks

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# Welcome

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**Pekka Lundmark**  
President and CEO

- 4. Our investor communication plan
  - 5. Strategy milestones reached in 2021
- 



**Tommi Uitto**  
President Mobile Networks

- 8. Recap of March CMD
- 9. Securing product competitiveness
- 19. Addressable market trends
- 23. Leadership in O-RAN and Cloud RAN

# Investor communication plan

Periodic BG progress updates to increase transparency

## Improving our investor communication

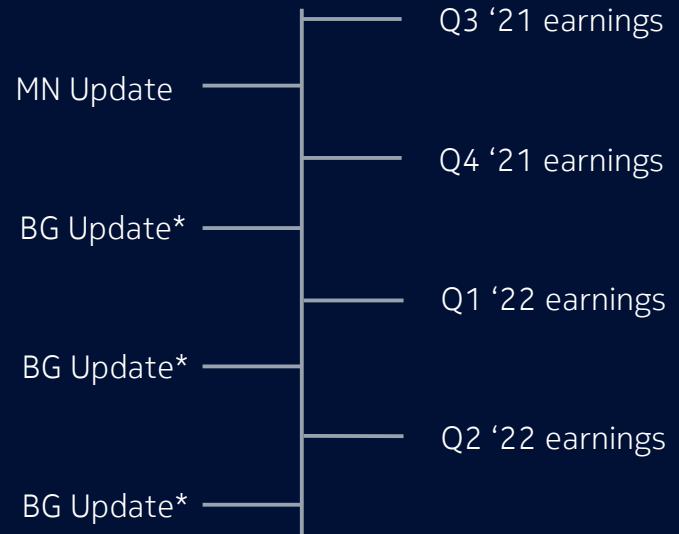
Streamlined financial reporting

Transparency to business performance

Balanced and transparent outlook

Focus on ESG

## Periodic business group progress updates



\*Exact dates and order of business group updates is still to be confirmed

# Our reset phase is on track, accelerate ahead

Three-phased journey to deliver sustainable, profitable growth and technology leadership

2021 focus

2022 and mid term

## Reset

- Technology leadership on track
- Operating model on track
- Mobile Networks ahead of plan
- Lower cost base in progress
- Purpose and culture defined
- Leadership team complete

## Accelerate

- Enhance technology leadership
- Lead in O-RAN/Cloud RAN
- Drive 5G Advanced standard
- IP/Optical convergence
- Digitalization
- Automation
- Emerging opportunities
- Cloud / Network-as-a-Service

## Scale

- New use cases
- New business models
- Invest in 6G standardization

# Our strategy is improving our financials (Q1-3 2021)

Net sales

€15.8bn

Q1-3 2020: €15.3bn

Net sales growth y-o-y  
(constant currency)

+6%

EPS, diluted (comparable)

€0.24

Q1-3 2020: €0.11

Operating margin  
(comparable)

11.8%

Q1-3 2020: 6.7%

Gross margin  
(comparable)

40.5%

Q1-3 2020: 37.8%

Net cash

€4.3bn

Q3 2020: €1.9bn

# Mobile Networks

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Tommi Uitto  
President Mobile Networks

- 8. Recap of March CMD
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# We have delivered on what we promised at March CMD

## Recap of March CMD '21 plan:

### Reset

- ✓ Secure full portfolio competitiveness
- ✓ Continue 5G momentum with CSPs and for private wireless customers
- ✓ Launch Cloud RAN and O-RAN solutions
- ✓ Reset fixed costs

## What we have delivered:

AirScale portfolio launch in June 2021  
Industry's lightest high power 400 MHz 32TRX mMIMO antenna

Stabilised 4G/5G conversion ratio  
Private wireless customers expanded from 260 to 380+

June product launch O-RAN ready  
Nokia Cloud RAN in trials

Significant R&D productivity improvements  
Operating margin assumption raised in July 2021



# All bases covered to secure 5G technology leadership



New AirScale radios, including the industry's lightest high-power, 400MHz 32TRX Massive MIMO



Energy efficient AirScale baseband: industry benchmark for flexibility and capacity



On track to power full portfolio with ReefShark System-on-Chips in 2022



5G with Single RAN – common software trunk for speed and quality

‘Great to see you back in 5G ,

Johan Wibergh  
Group Technology  
Officer, Vodafone



# Our new SoC-based multi-radio baseband is now the industry benchmark

Leadership in the six product characteristics that matter in baseband platforms

Data throughput capacity

Subscriber connectivity

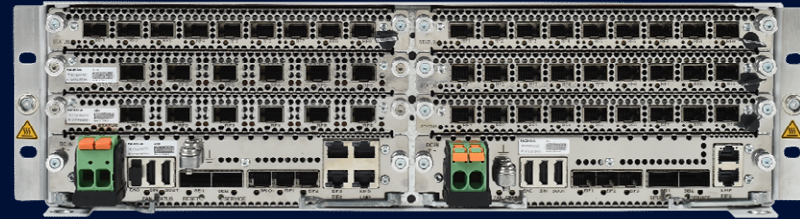
Cell connectivity

Power consumption

Scalability

Future-proofness

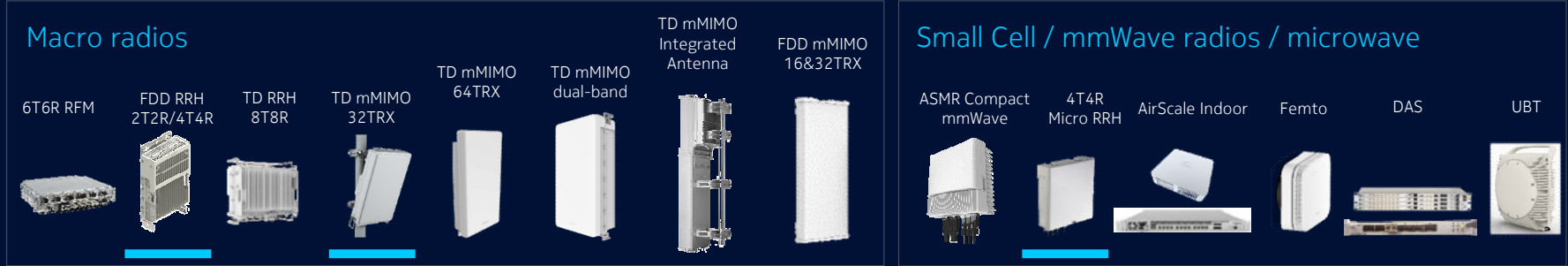
- 1 - 2 Common Units for L3 and Transport
- 1 - 6 Capacity Units for L1 and L2



Ultra-lean variant with same SoCs and SW

# Comprehensive radio portfolio for capacity and coverage

## Huge selection of 5G ready radios (FDD and TDD)



Over 5 million Nokia radios capable of supporting 5G

Over 260 radio variants in the Nokia portfolio

A choice of radios increases network performance and decreases site costs

# We are back on SoC path and “all bases are loaded”

## 5G Massive MIMO example

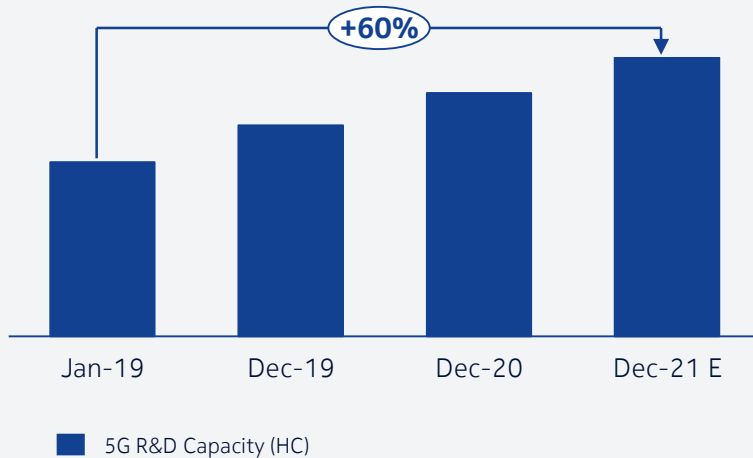
Compute function	2019	2020	2021	2022	2023
L1	Commercial large FPGA		ReefShark SoC		Next Gen ReefShark SoC
L2/L3/TRS	ReefShark SoC		ReefShark SoC		Next Gen ReefShark SoC
eCPRI	Commercial large FPGA		ReefShark SoC		Next Gen ReefShark SoC
RF DFE	Commercial large FPGA		ReefShark SoC		Next Gen ReefShark SoC
L1-Low Beamforming	Commercial large FPGA		ReefShark SoC		Next Gen ReefShark SoC



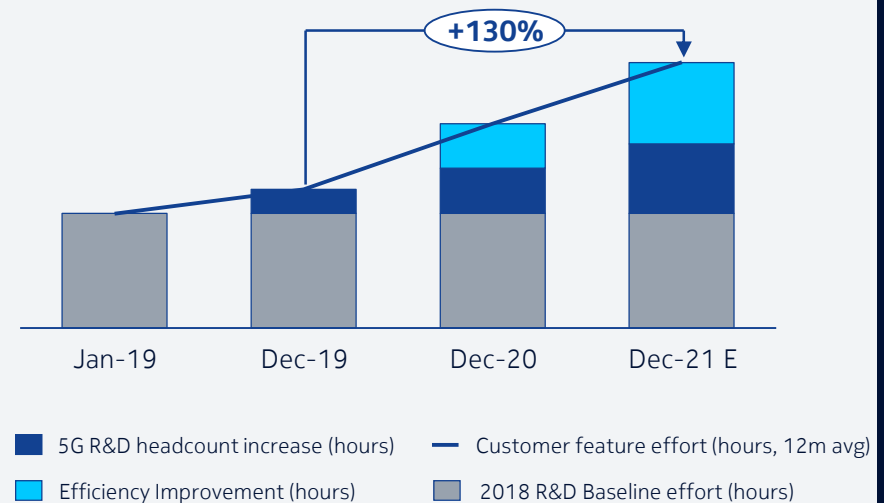
SoC design team size tripled – working with three SoC partners

# We made significant progress throughout 2019 – 2021 increasing R&D output and productivity

## Nominal 5G R&D capacity increase (headcount)



## Increase in 5G customer SW feature effort (hours)



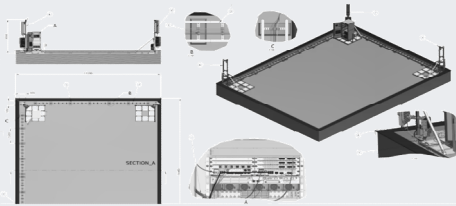
# Digitizing service delivery for speed, quality and TCO

## Driveless acceptance



- 75% time reduction for acceptance
- Manual to automated data processing
- Reduction of CO2 associated with drive testing

## Site design automation



- Simplify , improve quality and accelerate the site design process
- Site design based on the input collected during technical site survey
- Faster site design and lower TCO

## Intelligent issue resolution

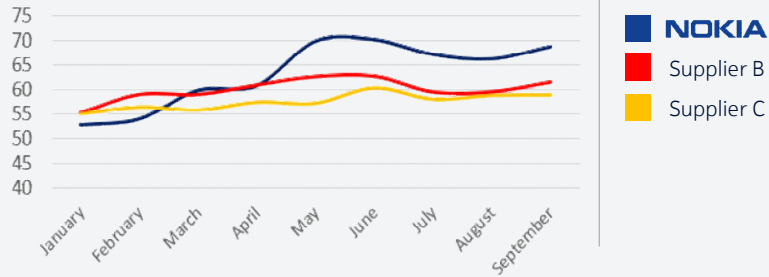


- Advanced selfcare and information access with Nokia Digital Assistant
- Automated log identification and collection
- AI based root cause analysis accelerating case handling

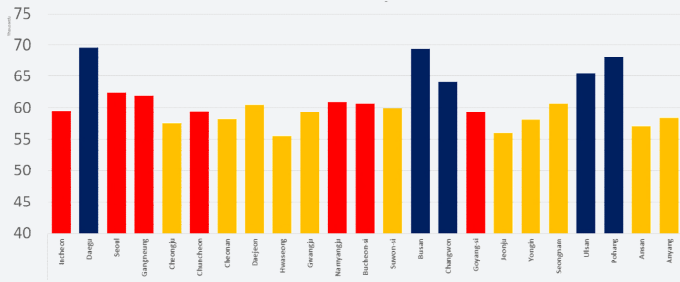
# Great Nokia 5G NSA performance development

## Crowdsourced data - major South Korean operator - 2021

5G NSA (ENDC) DL Throughput Trend (Mbit/s)

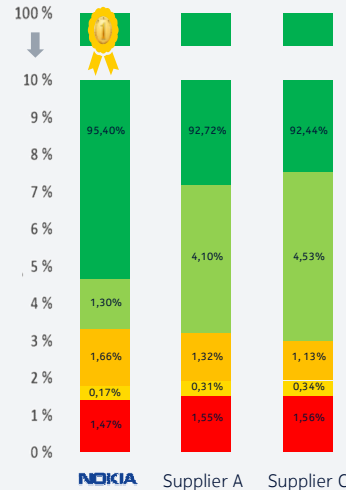


September City level DL Throughput (Mbit/s)

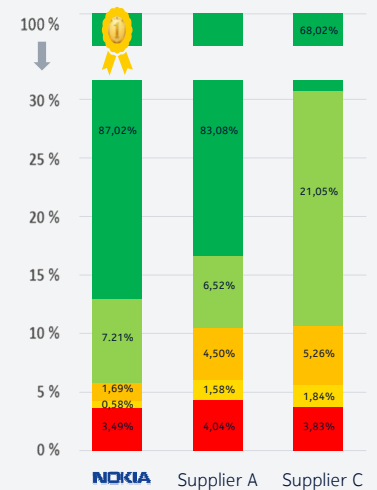


Nokia analysis based on crowdsourced data from Tutela Technologies, Ltd.

Video Conferencing\*



Cloud Gaming\*



Nokia analysis based on crowdsourced data from Tutela Technologies, Ltd. (1-31 Sept '21)

~40% of 5G networks in the world are powered by Nokia

30

New RAN  
customers since  
the start of 2019

23

Customers  
increased their RAN  
share with Nokia

~90%

4G to 5G  
conversion rate,  
excluding China

~25-27%


4G+5G market  
share, excl. China



# We are leading the market in private wireless networks

## Private wireless and IoT expand critical networks market into Enterprise

### Aircraft engine inspection over 5G

- Nokia 5G solution deployed by Lufthansa Technik for virtual engine part inspection. 
- Allows customers to remotely attend engine parts inspections.
- Entering pilot stage just prior to the pandemic the solution quickly demonstrated its value and quickly moved from trial to business-critical infrastructure.

### 5G SA for mining operation

- Operational 5G SA network deployed by Telia and Nokia for Agnico Eagle.
- Deployed at the Kittilä mine in northern Finland.
- Above and below ground operations.
- Connectivity of people, sensors, devices and vehicles up to 1km below surface.
- Enhances operational efficiency and supports highest level of safety.



Private Wireless Networks sold to 380+ customers via CSP or direct, of which 70+ are 5G

# Our Mobile Networks ambition expands beyond 2023

## Strategic focus

## Success factors

<b>Scale</b>	<ul style="list-style-type: none"><li>• Convert Nokia 4G CSP customers to 5G</li><li>• Continue winning new CSP customers</li><li>• Continue winning in Enterprise segment</li></ul>
<b>Product competitiveness</b>	<ul style="list-style-type: none"><li>• Build on product platform and R&amp;D turn-around</li><li>• Increase 5G R&amp;D capacity further</li><li>• Continue reducing product and service cost</li></ul>
<b>Shaping the market</b>	<ul style="list-style-type: none"><li>• Leading solutions for e2e slicing and private wireless networks</li><li>• Make O-RAN commercial reality to gain share</li><li>• Bring cloud computing benefits to mobile networks</li></ul>
<b>Resetting fixed cost base</b>	<ul style="list-style-type: none"><li>• Reap the benefits of the new operating model</li><li>• Significantly lower fixed cost base to fund R&amp;D increase</li><li>• Continue improving R&amp;D productivity</li></ul>

Comparable Operating Margin in 2023...

5%-8%

... and in longer term

10+%

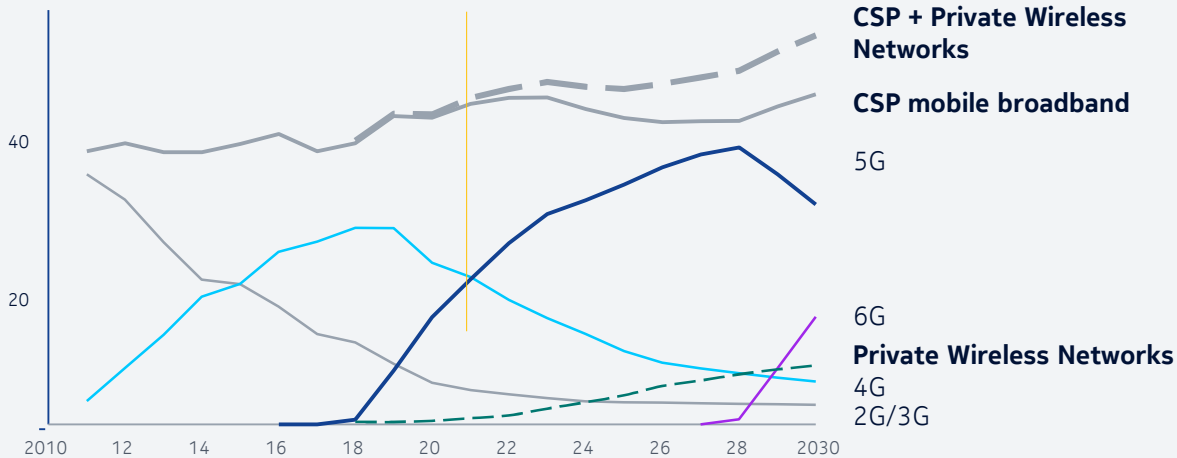


# Addressable market outlook

# The 5G market has an extended peak

## Private Wireless Networks market growing at 29% CAGR

Radio technology product and services market\* in EURbn constant



\*) excluding Mainland China

\*\*) Mobile Networks market size calculated assuming actual currency rates for first ten months of 2021 and end of October EUR/USD rate of 1.16 continues for the remainder of 2021. Growth rates based on constant currency.

Source: Nokia Business Intelligence

Overall Mobile Networks market\* growth 2021-24

2% CAGR

2021: €46bn\*\*

2024: €50bn\*\*

Private Wireless Networks market\* growth 2021-30

29% CAGR

# The future starts now

## 5G

- **Industrial 5G use cases** supported by classical and Cloud RAN / O-RAN solution
- **Network efficiency and optimization** utilizing 4G/5G slicing, AI/ML and energy efficiency

## 5G - Advanced

- **New 5G usage areas**, e.g. **5G satellite networks** and **Sub-5 MHz carrier** for railways and smart grid
- **Boosted 5G experience**, enhanced coverage, 50% higher energy efficiency with small packet optimisation
- **Boosted 5G services**, e.g. high accuracy and low cost **positioning methods** for e.g. industrial automation, IoT

## 6G

- **Seamless 6G evolution** of radio architectures, chipsets, software and 5G/6G platforms
- **Adaptive AI interface** and deep learning



# 5G Advanced provides new usage areas and services

## Expected characteristics of 5G-Advanced

### 5G Extension

Extending the reach of 5G to wider footprints and new use-cases

Link budget improvements; enhanced beamforming; reduced capability devices (RedCap).

### 5G Expansion

Expanding from providing the 'what' to the 'where and the 'when' with accurate precision and timing

High accuracy positioning; network timing; support for industrial automation and IoT.

### 5G Experience

Truly immersive digital experiences with extended reality

Edge Compute; cloud gaming; use case mobility enhancements; XR QoE.

### 5G Excellence in operations

Optimal cognitive use of available resources to deliver unprecedented performance

Traffic splitting and steering; energy efficiency measures.



# Leadership in O-RAN and Cloud RAN



# O-RAN was formed by operators to lower TCO

## RAN openness, programmability, HW vs SW separation



- Launched June 2018
- Merging of the xRAN Forum with the C-RAN Alliance
- O-RAN Alliance announced collaboration with TIP in February 2020
- 10 key working groups led by operators with vendors co-chairing

30

operators

290

contributors

## Objectives

1. Adopt **open RAN interfaces and infrastructure** to allow multi-vendor combinations
2. Achieve **faster time-to-market** and **easier innovation leverage**
3. **Efficient TCO** by increased competition and **white box approach**
4. Rapid and broad industry promotion, adoption of **open standards, interfaces and APIs**
5. **RAN programmability** and service optimization through leverage of AI and Machine Learning



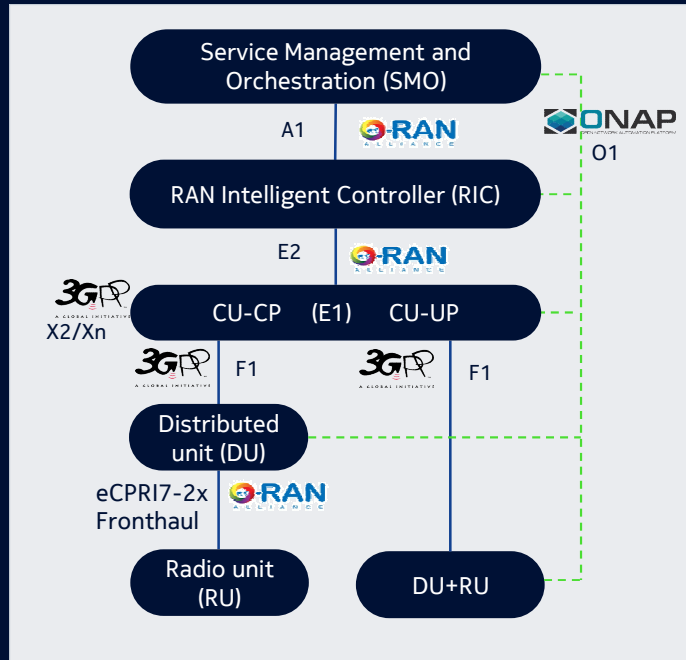
# Nokia active in all O-RAN working groups

## Co-leads RIC and Fronthaul groups



# Nokia active contribution / co-leading

O-RAN architecture – defines fronthaul specification and a new element RIC  
Functions and interfaces can be selected/deployed independently



## O-RAN architecture

### RAN Intelligent Controller (RIC)

- New virtualized function
- RAN programmability / Self Optimized Network type functions

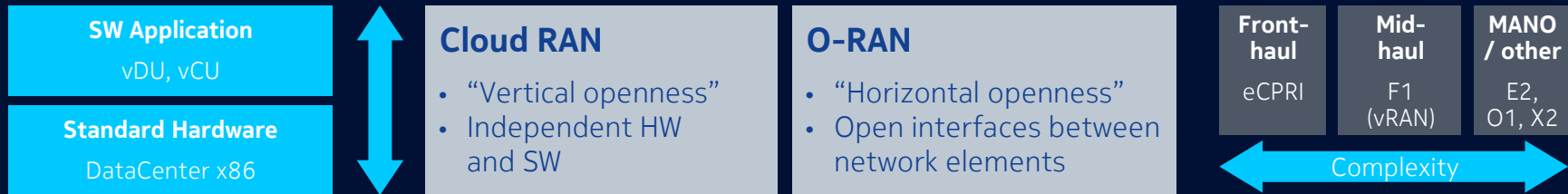
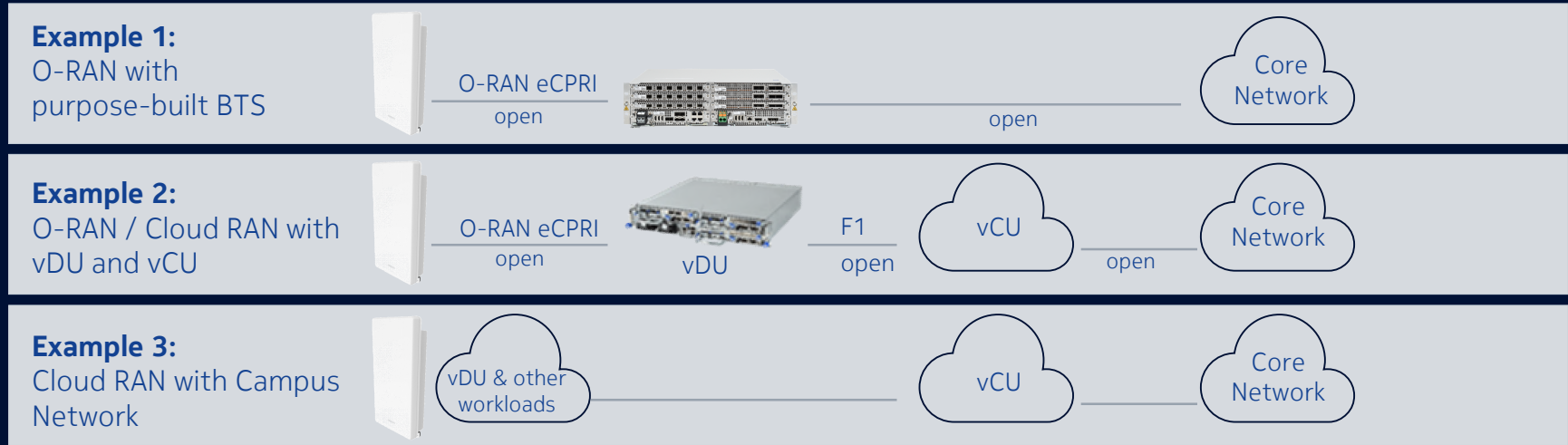
### O-RAN fronthaul

- Facilitates different suppliers for the DU and RU
- O-RAN alliance defines IoT profile interoperability testing (IOT) for O-DU and O-RU from different vendors

### Virtualization

- HW / SW separation of network elements (especially DU and CU)

# High level view of the difference between Cloud RAN and O-RAN



# O-RAN enables CSPs to deploy multi-vendor RAN solutions

Additional complexity, time-to-market and performance risks to be addressed

## How O-RAN can benefit operators

- **RAN programmability** for network optimization, new use cases and slicing.
- Stimulate **innovation** by open API and interfaces.
- More **flexibility in vendor selection** for RAN elements (e.g. RF and BB). Allows the insertion of **new players**. In theory could lower TCO.
- Reduce **vendor lock-in** with open interface between baseband and RF.

## Challenges to be addressed

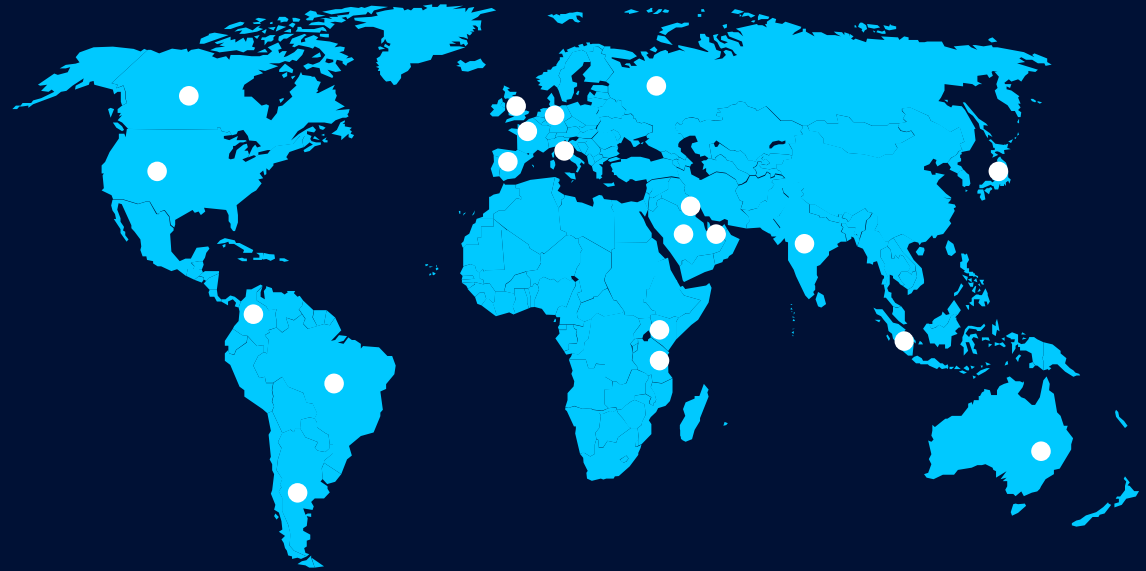
- Adoption **not consistent across major vendors**.
- **Need for system integration** to ensure feature alignment, performance and lifecycle management.
- **Co-existence and inter-working with legacy networks**
- Product **cost and power** consumption challenging as standard hardware not optimized vs. custom silicon.
- Possible **risk of industry fragmentation** leading to sub-scale vendors.

# Nokia O-RAN: Growing number of customer engagements

Strong interest in understanding Nokia's position in O-RAN ecosystem

Customer  
engagements

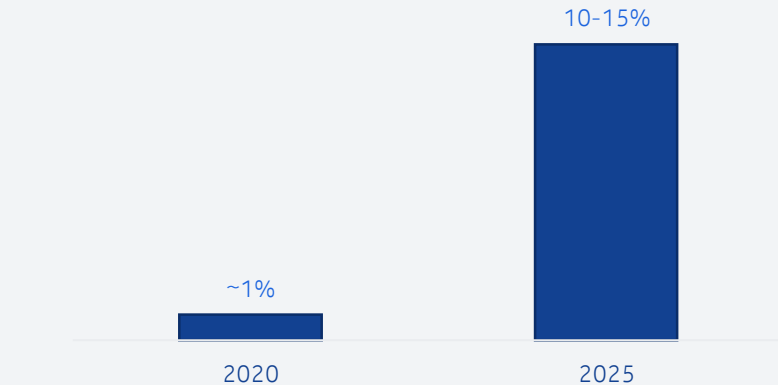
50+



# Open RAN penetration still limited through 2025

Dell'Oro forecasts 13% Open RAN and 6% vRAN share by 2025

Open RAN % Share of RAN market (by value)



Source: Dell'Oro

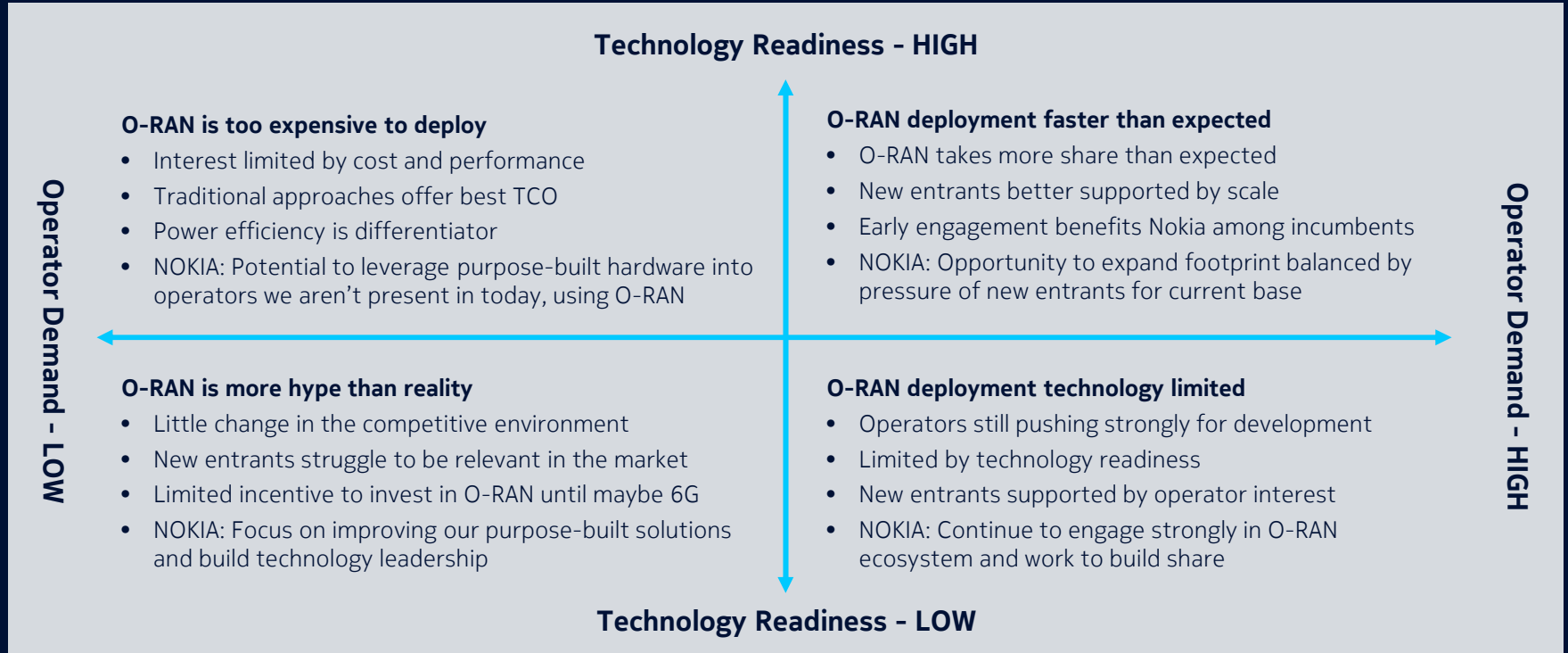
vRAN % Share of RAN market (by value)



Source: Dell'Oro

# O-RAN scenarios – a lot still to be determined

Our strategy should position us well no matter how quickly O-RAN evolves



# Conclusion

## **1. We have delivered on our objectives for Reset in 2021**

- We have closed the gap to competition
- Increased our R&D investments to drive towards technology leadership
- Stabilized our footprint after the challenges faced in 2019/20

## **2. We see a robust market demand through 2024**

- While market growth may slow – we still see 2% CAGR 2021-2024
- We remain optimistic on the pace of growth we might see in private wireless

## **3. O-RAN as much an opportunity as a threat**

- There is still much to be developed technology wise
- But we have a strategy that can deliver regardless of the speed of O-RAN adoption





# Q&A

**NOKIA**