Mobile Networks progress update

Pekka Lundmark
President and CEO

Tommi Uitto
President of Mobile Networks
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Welcome

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

- Q3 ‘21 earnings
- Q4 ‘21 earnings
- Q1 ‘22 earnings
- Q2 ‘22 earnings

*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

- Technology leadership
- Operating model
- Mobile Networks
- Lower cost base
- Purpose and culture
- Leadership team

2022 and mid term

- 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)

<table>
<thead>
<tr>
<th>Net sales</th>
<th>€15.8bn</th>
<th>Q1-3 2020: €15.3bn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net sales growth y-o-y (constant currency)</td>
<td>+6%</td>
<td>Q1-3 2020: +6%</td>
</tr>
<tr>
<td>EPS, diluted (comparable)</td>
<td>€0.24</td>
<td>Q1-3 2020: €0.11</td>
</tr>
<tr>
<td>Operating margin (comparable)</td>
<td>11.8%</td>
<td>Q1-3 2020: 6.7%</td>
</tr>
<tr>
<td>Gross margin (comparable)</td>
<td>40.5%</td>
<td>Q1-3 2020: 37.8%</td>
</tr>
<tr>
<td>Net cash</td>
<td>€4.3bn</td>
<td>Q3 2020: €1.9bn</td>
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</tbody>
</table>
Mobile Networks

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

Ultra-lean variant with same SoCs and SW

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

<table>
<thead>
<tr>
<th>Compute function</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
</tr>
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<tbody>
<tr>
<td>L1</td>
<td>Commercial</td>
<td>ReefShark</td>
<td>Next Gen ReefShark</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>large FPGA</td>
<td>SoC</td>
<td>SoC</td>
<td>SoC</td>
<td>SoC</td>
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<tr>
<td>L2/L3/TRS</td>
<td>ReefShark</td>
<td>ReefShark</td>
<td>Next Gen ReefShark</td>
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<td>eCPRI</td>
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<td>SoC</td>
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<tr>
<td>RF DFE</td>
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<tr>
<td></td>
<td>large FPGA</td>
<td>SoC</td>
<td>SoC</td>
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<td>SoC</td>
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<tr>
<td>L1-Low Beamforming</td>
<td>Commercial</td>
<td>ReefShark</td>
<td>Next Gen ReefShark</td>
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<td>SoC</td>
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</tbody>
</table>

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)

- Jan-19
- Dec-19
- Dec-20
- Dec-21 E

Increase in 5G customer SW feature effort (hours)

- Jan-19
- Dec-19
- Dec-20
- Dec-21 E

- 5G R&D headcount increase (hours)
- Customer feature effort (hours, 12m avg)
- Efficiency Improvement (hours)
- 2018 R&D Baseline 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

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

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

<table>
<thead>
<tr>
<th>Strategic focus</th>
<th>Success factors</th>
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<tbody>
<tr>
<td>Scale</td>
<td>• Convert Nokia 4G CSP customers to 5G</td>
</tr>
<tr>
<td></td>
<td>• Continue winning new CSP customers</td>
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<tr>
<td></td>
<td>• Continue winning in Enterprise segment</td>
</tr>
<tr>
<td>Product competitiveness</td>
<td>• Build on product platform and R&amp;D turn-around</td>
</tr>
<tr>
<td></td>
<td>• Increase 5G R&amp;D capacity further</td>
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<tr>
<td></td>
<td>• Continue reducing product and service cost</td>
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<tr>
<td>Shaping the market</td>
<td>• Leading solutions for e2e slicing and private wireless networks</td>
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<tr>
<td></td>
<td>• Make O-RAN commercial reality to gain share</td>
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<td></td>
<td>• Bring cloud computing benefits to mobile networks</td>
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<tr>
<td>Resetting fixed cost base</td>
<td>• Reap the benefits of the new operating model</td>
</tr>
<tr>
<td></td>
<td>• Significantly lower fixed cost base to fund R&amp;D increase</td>
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<tr>
<td></td>
<td>• Continue improving R&amp;D productivity</td>
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</table>

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

CSP + Private Wireless Networks
CSP mobile broadband
5G
6G
Private Wireless Networks
4G
2G/3G

Overall Mobile Networks market* growth 2021-24
2% CAGR
2021: €46bn** 2024: €50bn**

Private Wireless Networks market* growth 2021-30
29% CAGR

* 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
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

<table>
<thead>
<tr>
<th>Rel 15</th>
<th>Rel 16</th>
<th>Rel 17</th>
<th>Rel 18</th>
<th>Rel 19 - 20</th>
<th>Rel 21</th>
<th>Rel 22+</th>
</tr>
</thead>
</table>
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

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

- 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
Nokia active in all O-RAN working groups
Co-leads RIC and Fronthaul groups

- Use cases and overall architecture
- Operations and Maintenance
- Open X-haul Transport
- Stack Reference Design
- White-Box hardware
- Cloudification and Orchestration
- Non-real-time RIC and A1
- Near-real-time RIC and E2
- Open Fronthaul
- Open F1/W1/E1/X2/Xn

# 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

**Example 1:**
O-RAN with purpose-built BTS

- Cloud RAN
  - “Vertical openness”
  - Independent HW and SW

- O-RAN
  - “Horizontal openness”
  - Open interfaces between network elements

**Example 2:**
O-RAN / Cloud RAN with vDU and vCU

- SW Application
  - vDU, vCU

- Standard Hardware
  - DataCenter x86

**Example 3:**
Cloud RAN with Campus Network

- SW Application
  - vDU, vCU

- Standard Hardware
  - DataCenter x86
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
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)

- 2020: ~1%
- 2025: 10-15%

Source: Dell’Oro

vRAN % Share of RAN market (by value)

- 2020: <1%
- 2025: 5-10%

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

Technology Readiness - HIGH

- O-RAN deployment faster than expected
  - O-RAN takes more share than expected
  - New entrants better supported by scale
  - Early engagement benefits Nokia among incumbents
  - NOKIA: Opportunity to expand footprint balanced by pressure of new entrants for current base

Technology Readiness - LOW

- O-RAN deployment technology limited
  - Operators still pushing strongly for development
  - Limited by technology readiness
  - New entrants supported by operator interest
  - NOKIA: Continue to engage strongly in O-RAN ecosystem and work to build share

Operate Demand - LOW

- O-RAN is more hype than reality
  - Little change in the competitive environment
  - New entrants struggle to be relevant in the market
  - Limited incentive to invest in O-RAN until maybe 6G
  - NOKIA: Focus on improving our purpose-built solutions and build technology leadership

Operate Demand - HIGH

- O-RAN is too expensive to deploy
  - Interest limited by cost and performance
  - Traditional approaches offer best TCO
  - Power efficiency is differentiator
  - NOKIA: Potential to leverage purpose-built hardware into operators we aren't present in today, using O-RAN
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