Real-time eXtended Reality Multimedia

Tuomas Korpela, RXRM, 6 February 2025

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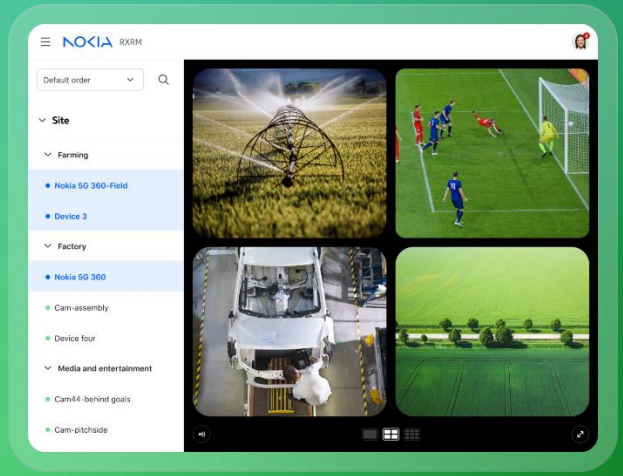


Nokia

Trusted performance across all network domains

Delivering resilient, superior performance across all critical parts of the network built on high standards of security, sustainability and ethics.

Networks as platforms for monetization

Providing extreme automation and APIs to manage and program the next generation of networks - creating new value in connecting to ecosystems of applications and services.

Truly open network architectures

Open architectures which seamlessly integrate into any customer or partner's ecosystem – across any server, CPU, RAN, cloud or software stack.

Enabling customers to realize the full potential of digital

Invest in secure, futureproof technology

Simplify to reduce costs

Expand into new opportunity areas

Drive sustainable efficiency

Technology Strategy 2030

Nokia Technology Strategy

Artificial intelligence, cloud and connectivity will reshape technology and the world

AI
Accelerating AI to advance business and society.

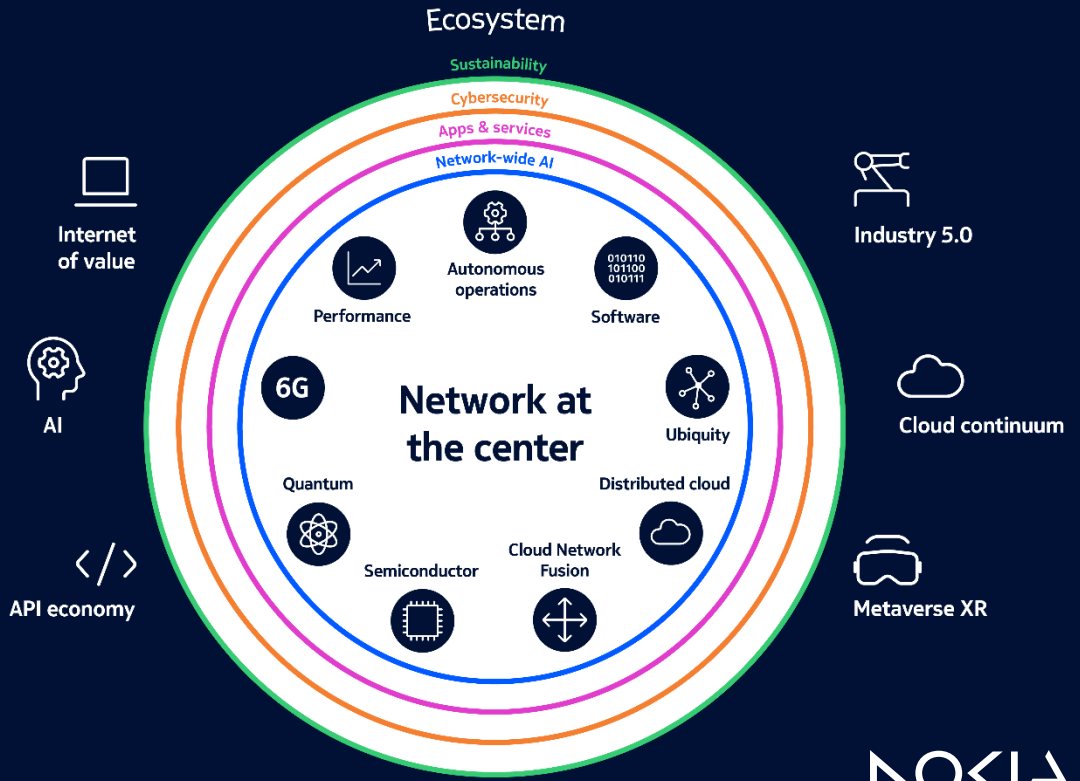
API economy
Implementing a comprehensive API strategy produces value, from the outside in, for digital organizations and partners.

Cloud continuum
Transforming multiple cloud environments from siloed to seamless.

Industry 5.0
Combining the creativity of humans with the efficiency of machines.

Internet of Value
Transferring value as easily, cheaply and reliably as data is transferred today.

Metaverse (XR)
Improve productivity across human, physical and digital worlds.



Our focus

Business models and monetization

Enabling new business models with technology.

Metaverse

Building metaverse ecosystem and value creation beyond connectivity

6G

Leading the industry in 6G development and first partner of choice

Enterprise

Delivering solutions that build and run tomorrow's enterprise networks

Devices & media

Innovating capabilities as a part of the device ecosystem for greater enablement across industries

Networks

Leading fixed and wireless networks, pioneering future network design using emerging technologies.

Applications & services

Enabling organizations monetize emerging value chains in a fast-growing API economy

Consumability

Offering technology solutions that are simple and easy to use

Software

010110
101100
010111

Delivering high-performance, intuitive software that is scalable and optimized using innovative technology

AI & data

Developing AI-wide networks providing a more cognitive, automated and ultra-responsive network infrastructure

Security

Ensuring security by design with zero trust principles and automation

Semiconductor

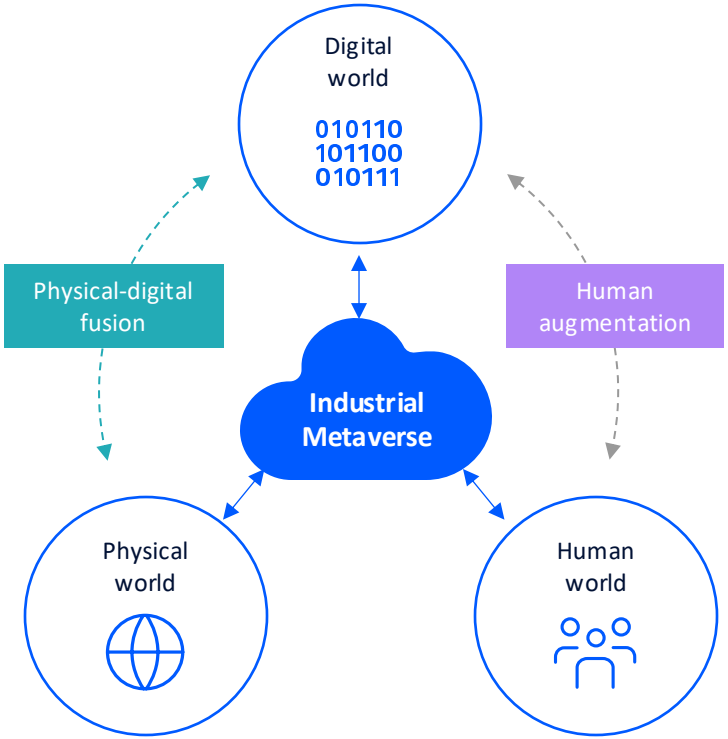
Developing cutting edge technology, silicon integration with emergent technologies and IP development

Sustainability

Using emergent technologies and circularity to reduce energy use and adverse environmental impacts

The industrial metaverse is physical-digital fusion and human augmentation.

Bringing together the digital, physical and human worlds



Physical-digital fusion

Dynamic, connected representations of real-world things in the digital world

Allows the physical world to be replicated, simulated and automated within the digital world, opening doors to a wealth of new possibilities for human benefit.

Human augmentation

Extensions that enable people to interact with and within the digital world

Evolves the digital world from being a source of two-dimensional experiences and information, to a focal point of immersive and productive interaction

“No one can own the metaverse. We need collaboration to build it.”

Pekka Lundmark

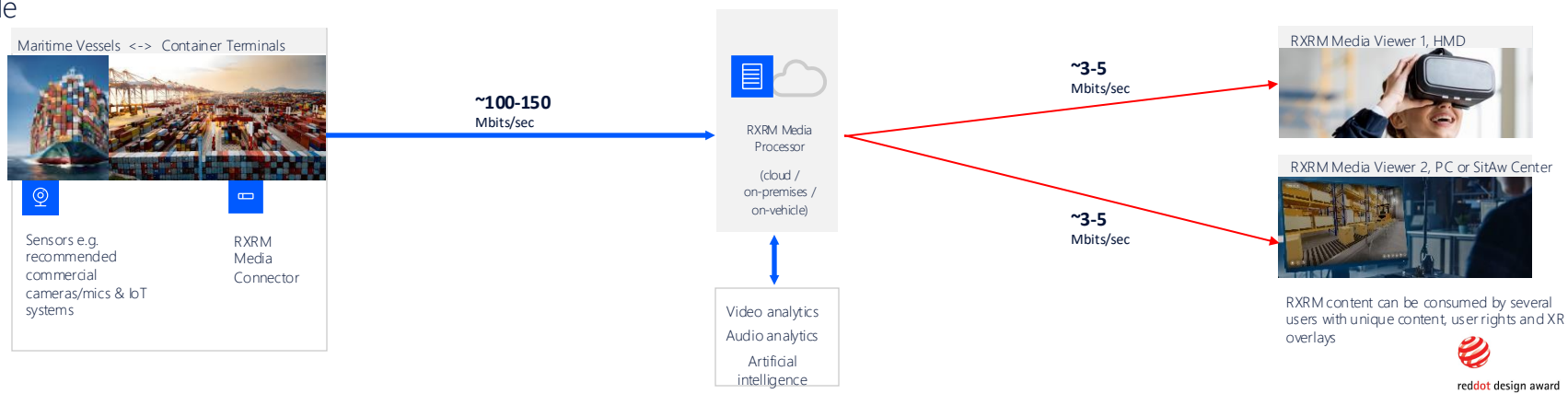
Keynote speech to Brooklyn 6G Summit, 2022

Real-time eXtended Reality Multimedia RXRM

Real-time eXtended Reality Multimedia RXRM

Increase the accuracy and speed of what you see - and hear - to a fraction of a second

Example



- Truly wireless and mobile experience
- Real-time 360° view
- Very low latency
- Resolution up to 8K
- Frame rate up to 60 fps
- Bandwidth optimization reduced up to 90% or more
- OZO spatial audio for industrial sensing

Software solution for 360° video and audio capture with XR overlays

Key use cases: Situational awareness, remote technical support, safety and security, industrial automation and teleoperations, training

Fully local deployment: as well as cloud based, multitenant services

Public Real-time eXtended Reality Multimedia (RXRM) references

Remote monitoring, training, telemedicine, teleoperation and smart city solutions

Telemedicine, remote monitoring, remote inspection, and remote telepresence for hard-to-reach areas

MINE FOR BUSINESS
CALLIO
PYHÄJÄRVI, FINLAND

Callio Pyhäsalmi test mine – remote surveillance and training in private 5G network

TAMPERE.
FINLAND

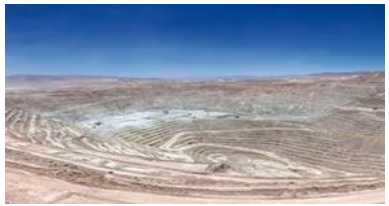
Immersive, creative smart city experiences in culture in CSP network

TURKU AMK
TURKU UNIVERSITY OF APPLIED SCIENCES

Utilizing RXRM as platform for custom
XR development for maritime industry remote monitoring
and training.

Non-public RXRM references and Nokia Arena incubation

Teleoperation and immersive event experiences



Global leader in mining

Utilizing RXRM as teleoperation and security solution to **optimize uplink bandwidth** for **real-time multimedia** in capacity constrained network

Leading port vehicle manufacturer

Autonomous vehicles needed **improved multimedia** capabilities, in which the customer and Nokia tested the RXRM solution in real environment

Scandinavian service provider

Reliable teleoperations for the forestry sector in harvesting in CSP network

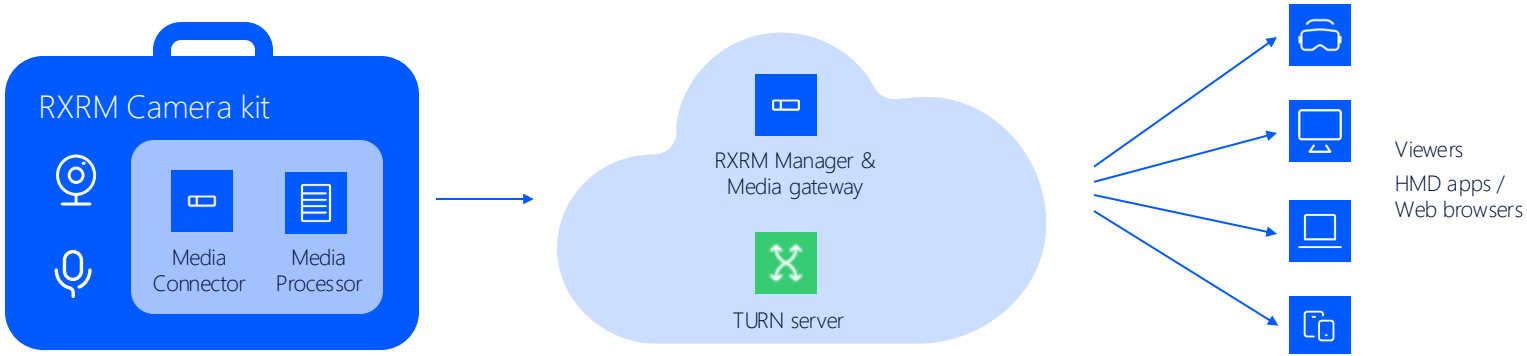
Nokia Arena

VIP boxes and HMD user experience of **ice hockey** events, and proof-of-value **real-time concert** for remote audience

Cloud-native deployment available now

Expanding RXRM’s versatile deployment options

- In addition to local edge deployment, RXRM can now be installed in a private, public or hybrid cloud
- Cloud-native Kubernetes deployment for single tenants
- Close collaboration with large cloud service providers including HPE, Microsoft, Amazon, Google and IBM



Collaging combines multiple 2D streams into one

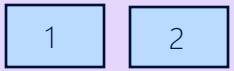
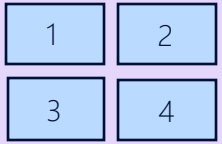
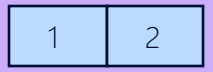
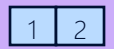
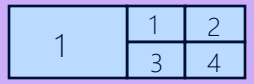
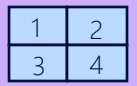
Limited field of view to save bandwidth

- Outputs fully synchronized streams from multiple 2D cameras via RXRM media gateway as one stream
- Offers significant bandwidth savings by lowering the stream resolution of selected cameras
  - Dependent on use cases and usage of the streams (display resolutions, stream size inside display etc.)
- The new API enables you to select from pre-created user profiles
- Use your own UI or RXRM's player to select regions from the collage canvas

Bandwidth savings with the stream collaging

Achieve bandwidth savings by lowering the resolution of selected output streams.

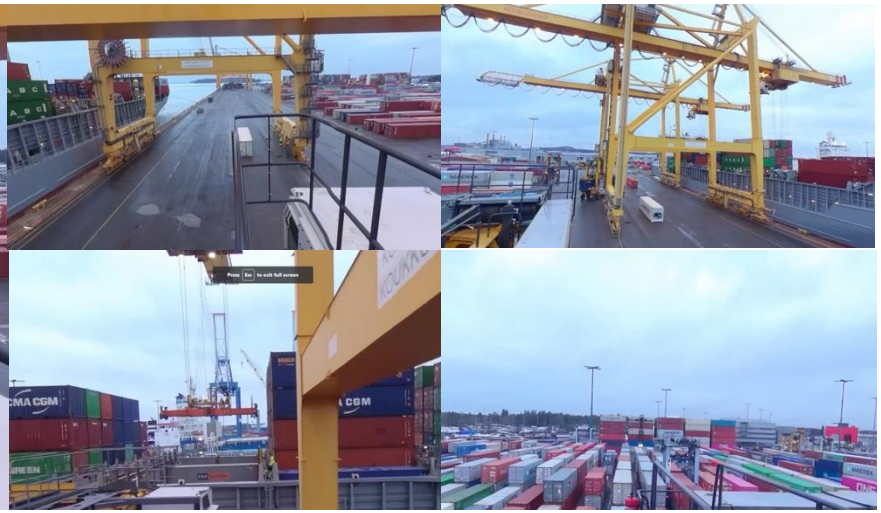
In the examples, all the original camera input streams are 1920 x 1080, 5 Mbit/s.

	Example 1: Two camera streams	Example 2: Four camera streams (with different resolutions)
Individual streams	 2 x 1920 x 1080 **~10Mbps**	 4 x 1920 x 1080 **~20Mbps**
With stream collaging	 2 x 1920 x 1080 = 3840 x 1080 **~10Mbps**	 4 x 1920 x 1080 = 3840 x 2160 **~20Mbps**
	 2 x 960 x 540 = 1920 x 540 **~ 2.5 Mbps**	 1 x 1920 x 1080 + 4 x 960 x 540 = 3840 x 1080 **~10Mbps**
		 4 x 960 x 540 = 1920 x 1080 **~ 5Mbps**

Choose to see the best angle

A collage canvas combines several 2D camera feeds all showing the same moment of time.

1920 x 1080

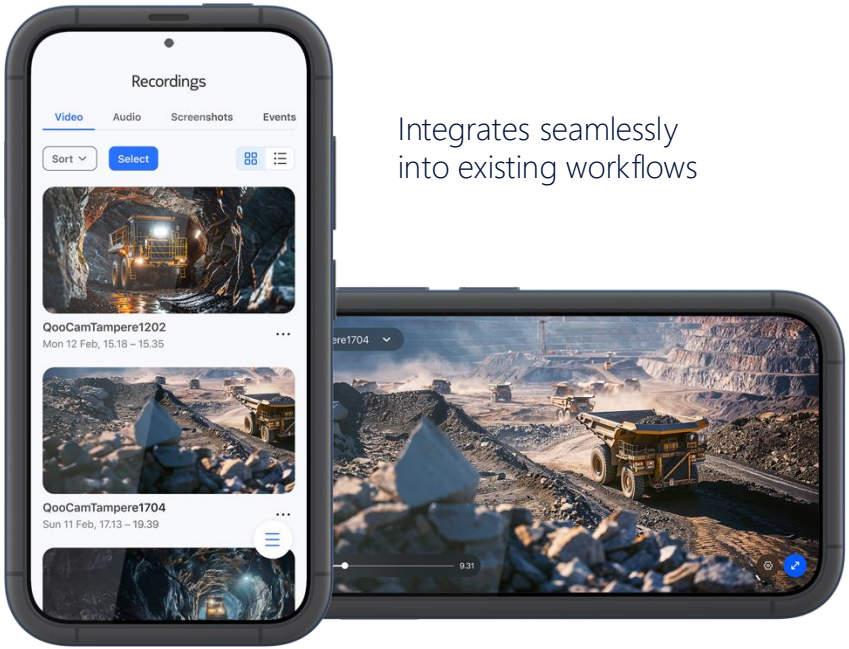


4 x 960 x 540

Smart phone optimized software and web UI

Boost productivity on the go

Responsive UX adapts to your phone size and resolution



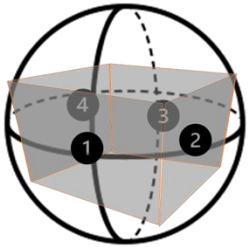
Integrates seamlessly into existing workflows

Supports live streaming and access to recordings

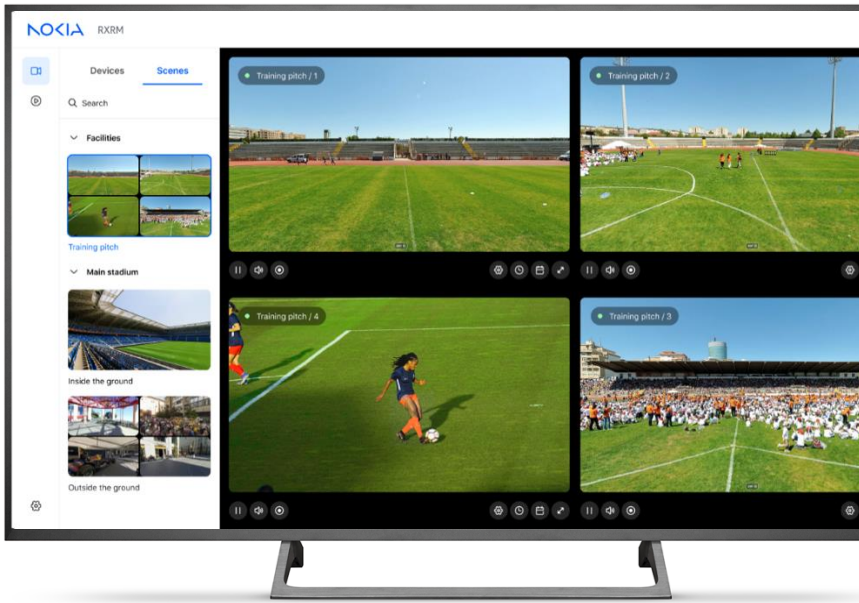
Fixed viewport stream publishing

Drop viewers at the heart of the action

- RXRM supports massively scalable video feed streaming. Fixed viewports of 360° streams can be published for CDNs and service providers to be broadcasted (such as Nokia CDN for Live)
- Streams are available via RXRM's media gateway module
- For broadcasting, end user can utilize either the CDN's or service provider's UI



An example of fixed viewports from a 360° stream



Software Architecture complies with existing infrastructure

Scalable architecture optimizes media delivery by bandwidth-efficient streaming.
It provides interfaces for easy integration of XR media, analytics and business workflows of the enterprise.

Multimedia sensor

Nokia - recommended commercial cameras

RXRM Media Connector

Nokia software running on supplier hardware

RXRM Media Processor

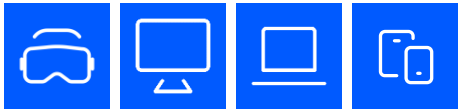
Nokia software running on supplier hardware with sufficient graphics performance.

RXRM Manager & Media gateway

Nokia software running on supplier hardware. Can be connected to Nokia or 3rd party video and audio analytics and external data sources (IoT)

RXRM Media Viewer App/plug-in

Nokia software running on selected vendor hardware.



Low-latency connectivity (LAN, 5G, LTE, WIFI) or TelCo network

Enterprise business workflow Integration (web services and APIs provided by customer, partners and RXRM)

Open API

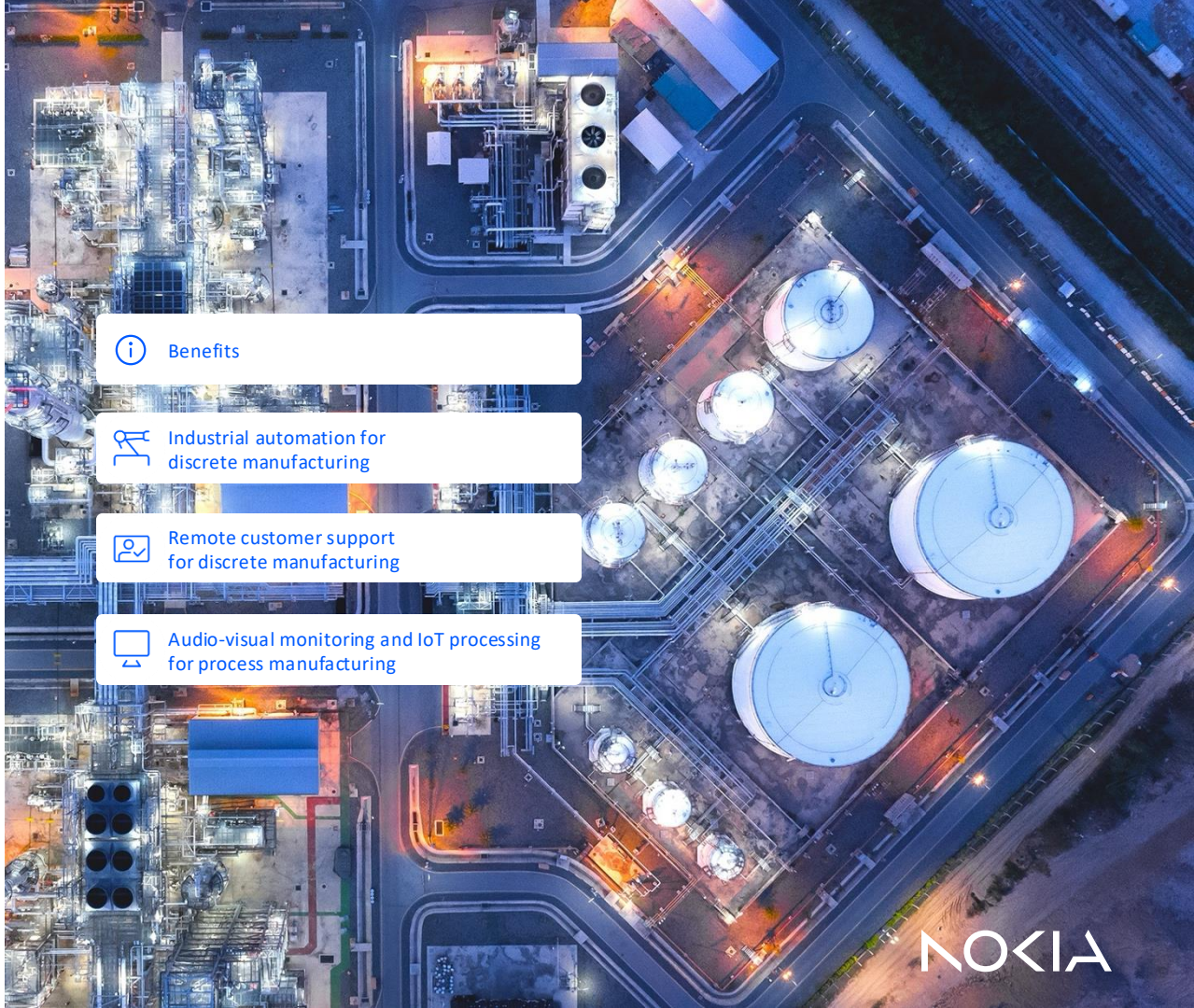
Integrating multimedia streams in a complex world

RXRM is open to third-party APIs, enabling different software systems and applications to communicate and integrate with RXRM. These systems include, for example, video and audio analytics, IoT data collection systems, and digital-twin solutions.

RXRM provides multimedia streams that can be consumed by third-party solutions. Information from these systems can then be utilized and visualized for the end user as overlays on top of a multimedia stream.

RXRM for Manufacturing

Quality. Efficiency. Consistency. These are three core requirements in manufacturing – and three areas in which RXRM enables businesses to excel. 360° video and 3D spatial audio open up new possibilities in manufacturing processes for both discrete and process applications.



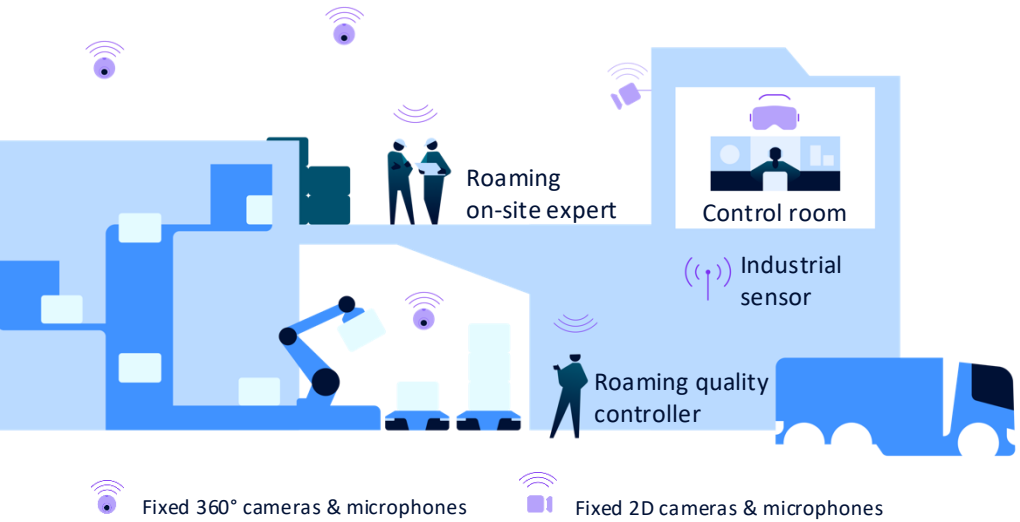
- ↓ Industrial monitoring
- ↓ Situational awareness
- ↓ Remote technical training
- ↓ Anomaly detection
- ↓ **Digital twinning**
- ↓ All general use cases

Benefits

- Ultra HD 360° audio-visual capabilities revolutionize automation abilities for both discrete and process manufacturing scenarios
- 8K resolution at 60 FPS provides remote visibility that outperforms the human eye in many situations
- Remote customer support combined with predictive diagnostics results in faster problem resolution and a decreased risk of downtime
- Real-time monitoring of inventory levels

Industrial automation for discrete manufacturing

Greater efficiency and smoother processes



Multimedia capture

A network of cameras and microphones provides superior situational awareness.

- Fixed 360° cameras & microphones
- Fixed 2D cameras & microphones
- Industrial sensors & microphones

Multimedia consumption

A team on the factory floor, in the onsite control center and in remote locations respectively are supported by video data analytics for semi-automated quality monitoring and control.

- 3rd party data analytics processor
- External IoT data
- Roaming quality controller
- Roaming on-site expert
- Control room
- Remote expert

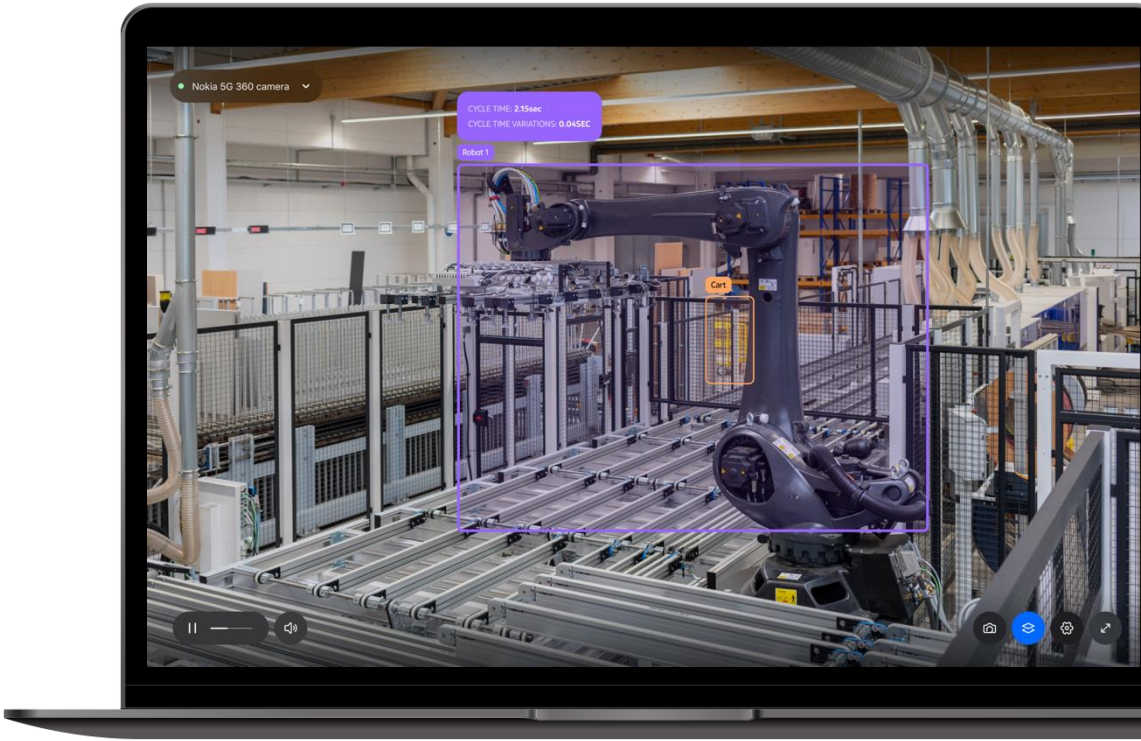
Industrial automation for discrete manufacturing

Quality control and audio-visual analytics

RXRM enables almost complete automation of industrial monitoring and quality control processes, utilizing video data analytics to check for issues or irregularities. Should an issue arise, a remote expert can be alerted.

With RXRM, you can also get access to third-party APIs. These can be used by video and audio analytics consultants and readily adapted to your needs.

Audio and visual information can be transmitted from a roaming quality controller to both the remote expert and control room. All three parties have ready access to the same data.



Remote customer support for discrete manufacturing

A better customer service with fewer resources

Multimedia capture

An onsite technician can relay issues arising on the factory floor.

- On-site technician with mobile 360° camera & microphone
- Industrial sensors & microphones

Multimedia consumption

The equipment vendor's remote specialist provides specialist technical assistance from a remote location.

- Remote expert can assist in real time through a live discussion
- Recorded content can also be sent to a remote expert

Remote customer support for discrete manufacturing

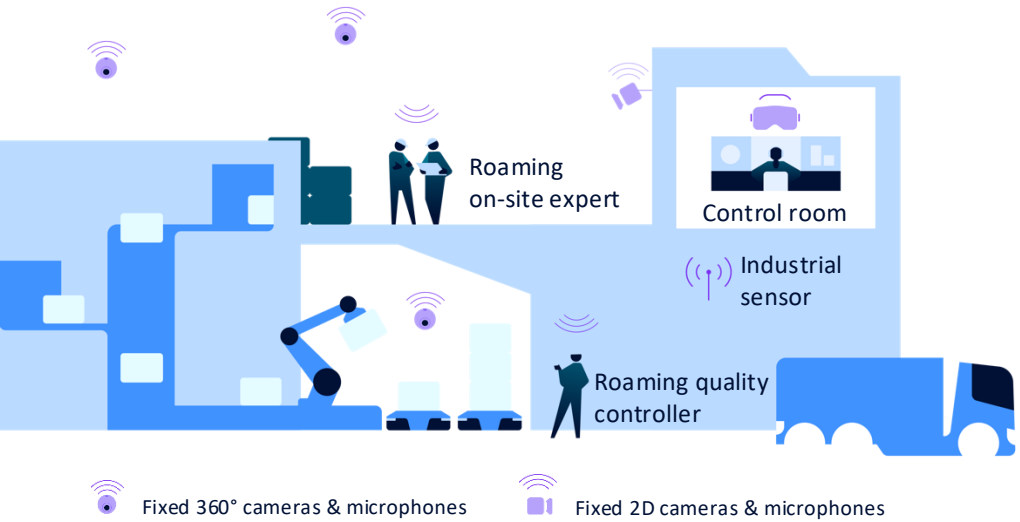
Immediate expert assistance

Equipment vendors can offer remote maintenance and customer support using 360° cameras and analytics, which often outperform humans in identifying problems. The onsite individual presents the relevant scene to the remote technical expert using a mobile camera, and the expert responds with immediate insight and guidance.

This approach not only substantially reduces travel costs, but also ensures customers receive specialized care in a fraction of the time previously needed.

Audio-visual monitoring and IoT sensoring for process manufacturing

Every step of the process covered



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Multimedia consumption

Team on the plant floor, in the onsite control center and in remote locations are supported by video data analytics for semi-automated quality control and monitoring.

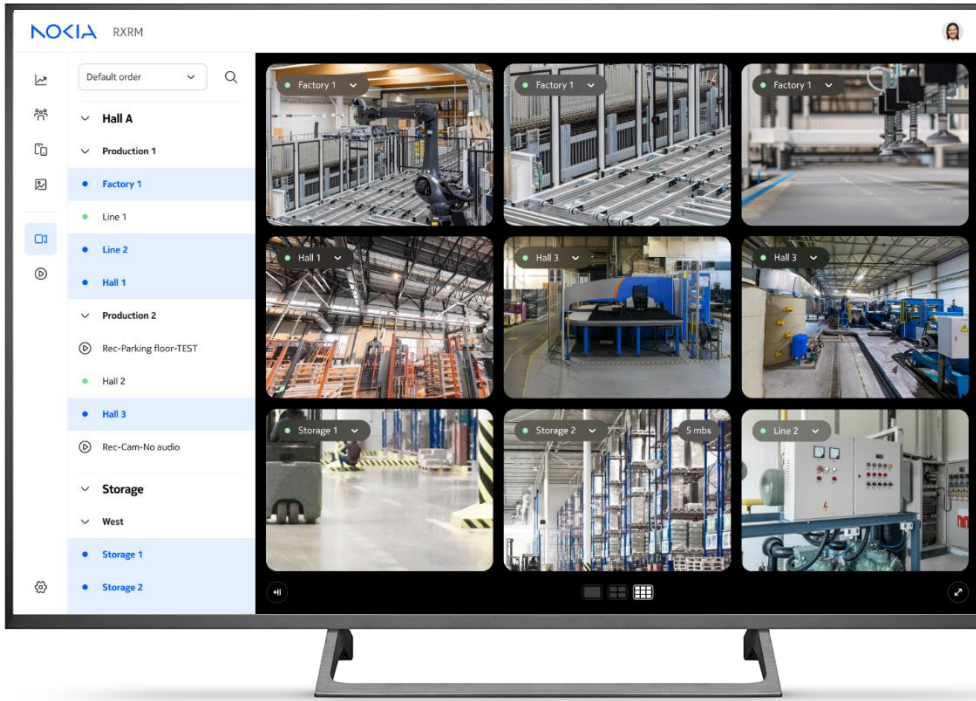
- Roaming on-site expert
- Roaming quality control
- Supervisor in onsite control room
- 3rd party data analytics processor
- External IoT data
- Remote expert

Audio-visual monitoring and IoT sensoring for process manufacturing

Multi-channel monitoring

This monitoring setup facilitates an immediate and comprehensive communication channel, with video and audio between all relevant parties.

Helps to ensure that processes are streamlined and systematic.



  Apply a document ID (if applicable).

Nokia RXRM with Nokia 5G 360 Camera

A combination of these features has been lacking

Ability to both record and stream 360° video

Fast enough video streaming for real-time teleoperation

Designed for harsh environments

An integrated robust connectivity solution for truly wireless operation

Spatial microphone with streaming capability

8K quality video streams without congesting the network

Nokia 5G 360 Camera

Designed for harsh industrial conditions and it comes with cyber-secure software and built-in security hardware; vertically integrated with RXRM solution

8K quality video streams without congesting the network

8K

Spatial microphone with streaming capability

Ability to both record and stream 360° video

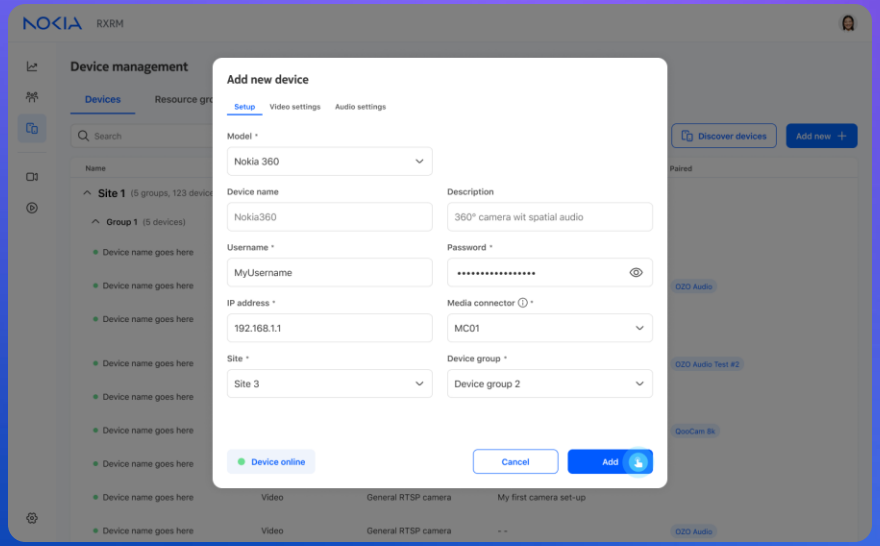
An integrated robust connectivity solution for truly wireless operation

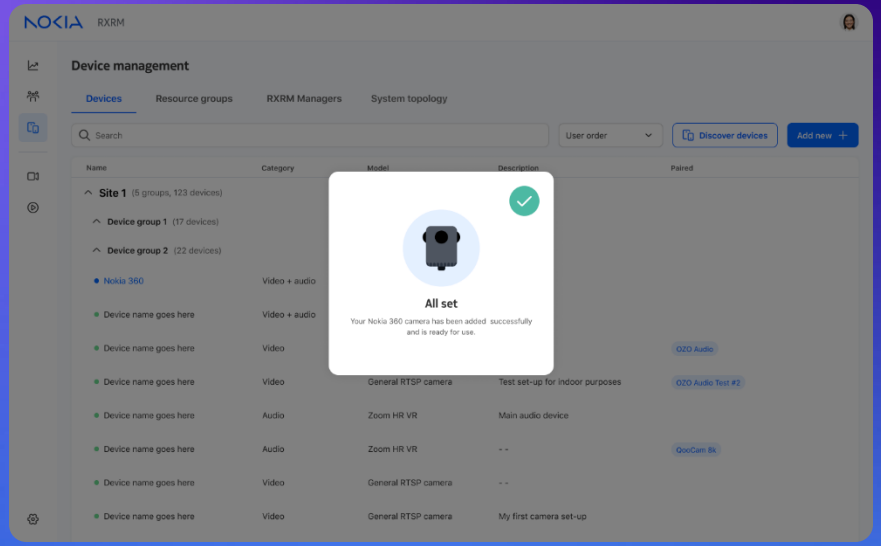
Designed for harsh environments, IP67

Fast enough video streaming for real-time teleoperation

Why Nokia 5G 360 Camera instead of a camera with limited Field of View (FOV)?

Together with RXRM solution and UX





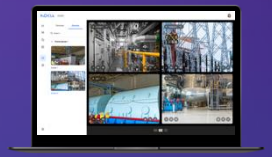
- 360° output available for AI analysis and storage
- Customized design with branding available on demand (color, logo, possibly material options)
- Additional accessories available (e.g. mounting solutions, protective casings)

Complete solution by Nokia

Nokia 5G 360 camera

- IP67 rated industrial 360 camera with spatial audio capture
- Integrated wireless connectivity for mobility and easy re-deployment
- Minimized capture-stitch-encode-transmit latency or <150ms (camera-only latency)
- Integrated OZO spatial audio recording functionality

Nokia RXRM



- Low latency high resolution immersive video streaming solution*
- Saves network capacity by reducing data rate up to 90%

Nokia industrial devices

- Nokia Mission Critical Industrial Edge (MXIE)
- Nokia 5G routers
- Nokia 5G Fixed Wireless Access devices

Nokia 5G 360°Camera features

Global connectivity and high bandwidth

Multi-band antennas providing global coverage

- 4x 5G/LTE, 2x 5G mmWave, 2x WiFi
- 5G/LTE benefits

Uninterrupted connectivity on the move

Secure and reliable data transfer

- Advanced high capacity and low latency technologies (5G mmWave)
- Plug-and-play without complex network configurations
- Simple deployment and re-location based

Nokia 5G 360 Camera	
Operating bands (5G FR1)	N1/n2/n3/n5/n7/n8/n12/n13/n14/n18/n20/n25/n26/n28/n30/n38/n40/n41/n48/n66/n71/n77/n78/n79
Operating bands (5G FR2)	n257/n258/n260/n261
Operating bands (LTE)-FDD	B1/B2/B3/B4/B5/B7/B8/B12/B13/B14/B17/B18/B19/B20/B25/B26/B28/B29/B30/B32/B66/B71
Operating bands (LTE)-TDD	B34/B38/B39/B40/B41/B42/B43/B46/B48
Modem solution	SDX65
mmWave IF solution	SMR545

High quality and low latency video streaming

- 8K Resolution in live streaming
- Low latency video streaming (< 150ms camera latency)
- Integrated spatial audio capture
- Enhanced low light performance (Visible Spectrum and Infrared modes) with Sony Starvis2 image sensors

Normal camera

IR mode with external IR lighting

Designed for harsh environments (IP67)

Built and tested for harsh environments and greater mobility

- Vibration and shock resistant, dust and waterproof
- Industrial grade 5G connectivity without protruding antennas or easily breakable parts
- Simple and versatile mounting solution
- Native support for Nokia Industrial Device Management (TR069)
- PoE powered device to reduce deployment complexity

Secure and reliable long-term performance

Guaranteed device security and information privacy

- Reliable operation with tamper resistant software and in-built security hardware
- Safe-boot and software signing for device security
- Long term operation verified with extensive software and hardware testing
- No requirement to enrol in any third-party services to use the device
- Possibility to encrypt device communication and video stream
- AI based face and license plate recognition and blurring
- In-device secure, encrypted video recording
- Key components from trusted vendors

Next steps

Limited trial samples available
January 2024

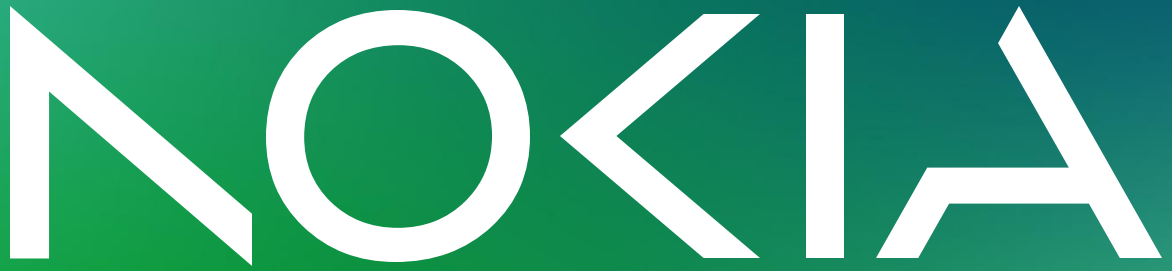
Mass production ready
April-May 2025

Lead times:

- Trial samples: contact RXRM BD
- Commercial units: 3-4 months (unless readily in stock)
  - Non-forecasted lead time depends on material availability
- Customized units (e.g. device surface customization): 4-5 months

Nokia as a hardware supplier

- Nokia has a long history of producing iconic and well-designed imaging and multimedia products
- Nokia products are developed with Secure Development Lifecycle methodology, fulfilling strictest product security requirements
- Nokia products fulfil the GDPR and related privacy regulations
- End to end system provider, optimizing network bandwidth and offering state-of-art extended reality multimedia systems
- Nokia products comply with industry standards and implement state of art technologies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