NR evolution – realizing the full potential of 5G

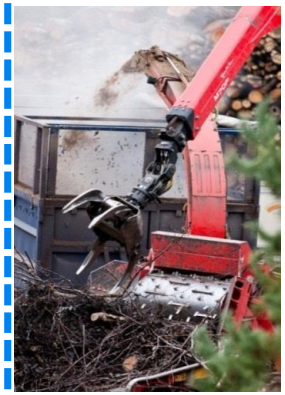
Janne Peisa,
Principal Researcher, Ericsson Research

5G – Beyond Mobile Broadband

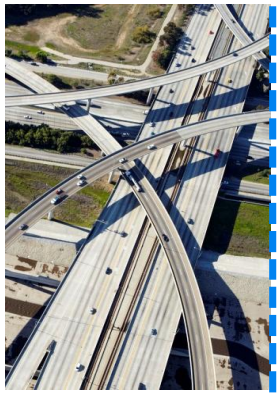
Broadband experience everywhere anytime

Mass market personalized media and gaming

Meters, sensors, “Massive MTC”



Remote controlled machines



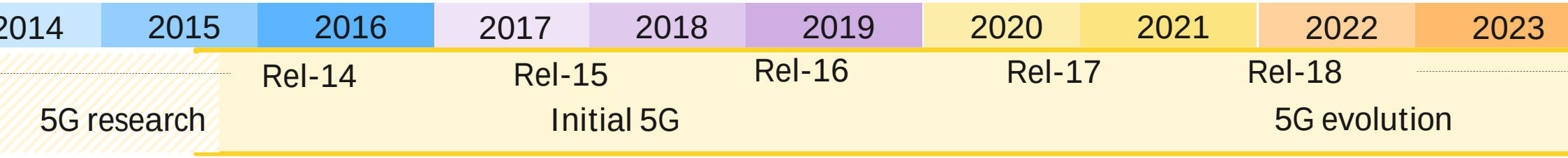
Smart Transport Infrastructure and vehicles

Human / machines interaction

And much more!

New opportunities and flexibility for the unforeseen

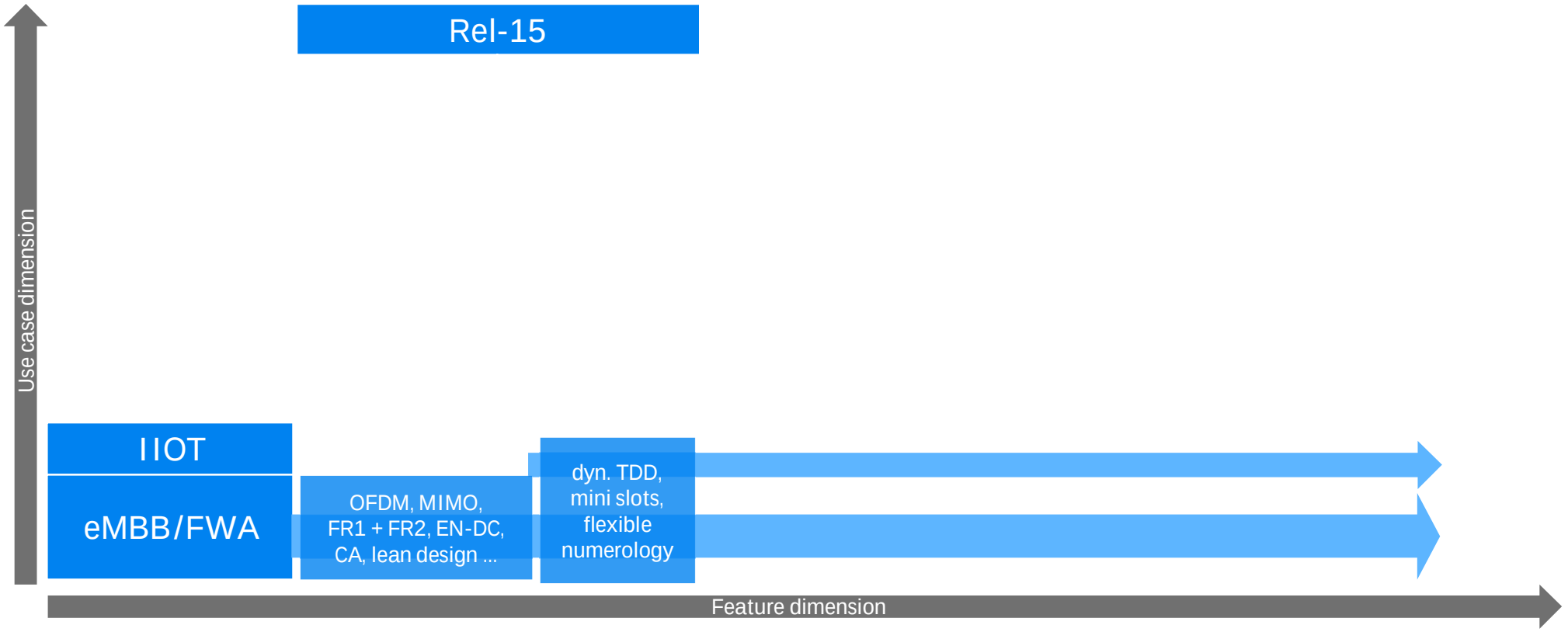
Wireless-access evolution – Timeline



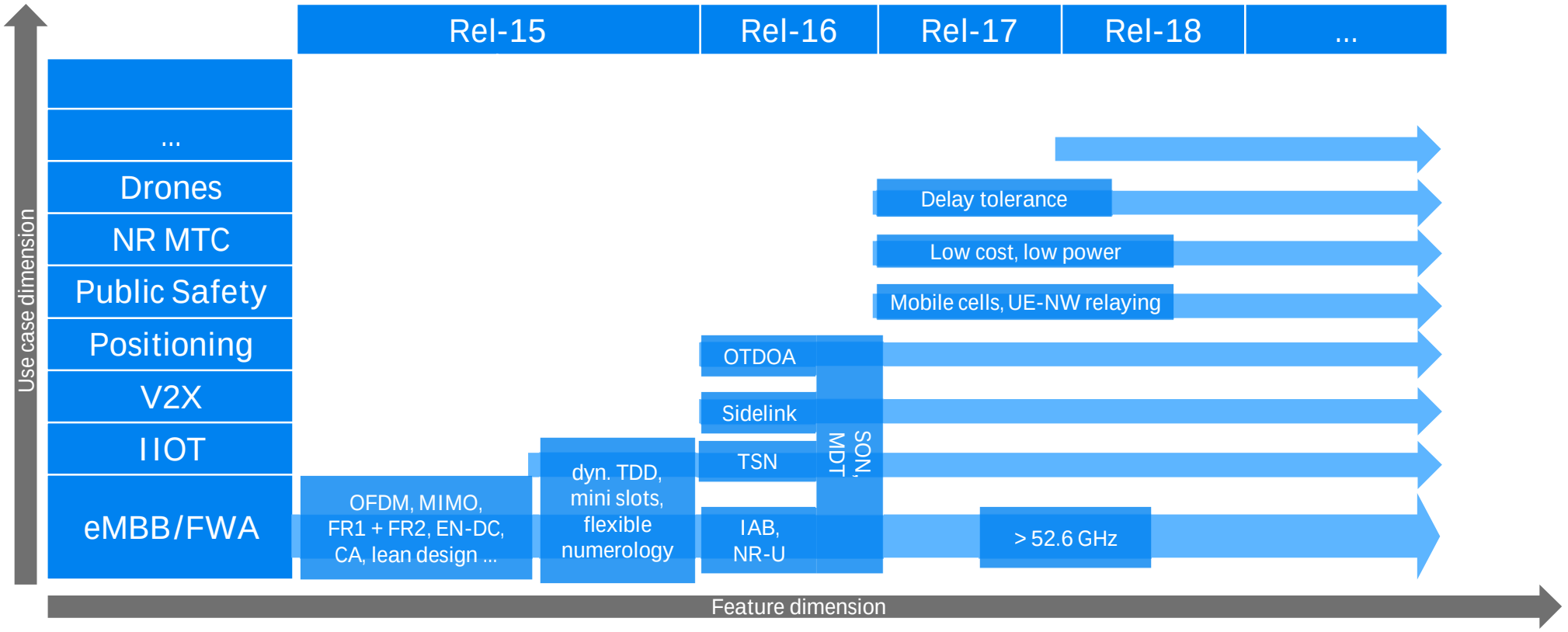
— First release of NR (Rel-15) completed in June 2018

— Evolution of NR
  — First major enhancements already in Rel-16 (IAB, NR-U, …)
  — Continued evolution in subsequent releases including frequencies up to and beyond 52.6 GHz, massive MTC, …

NR Rel-15

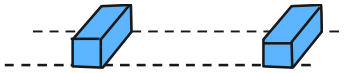

Rel-15
Use case dimension
IIOT
eMBB/FWA
OFDM, MIMO,
FR1 + FR2, EN-DC,
CA, lean design ...
dyn. TDD,
mini slots,
flexible
numerology
Feature dimension

NR evolution

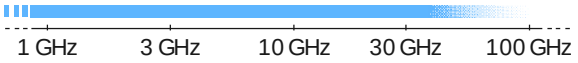


NR Rel-15 key features

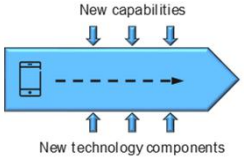
Ultra-lean design



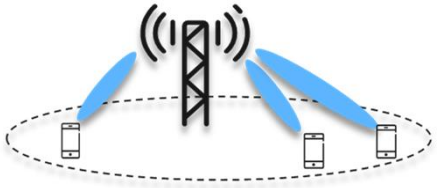
Wide spectrum range



Forward compatibility



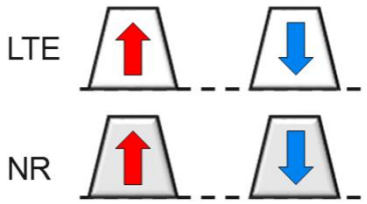
Multi-antenna support



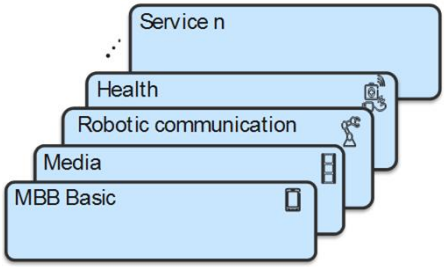
Low latency

NR Rel-15 key features

LTE – NR coexistence

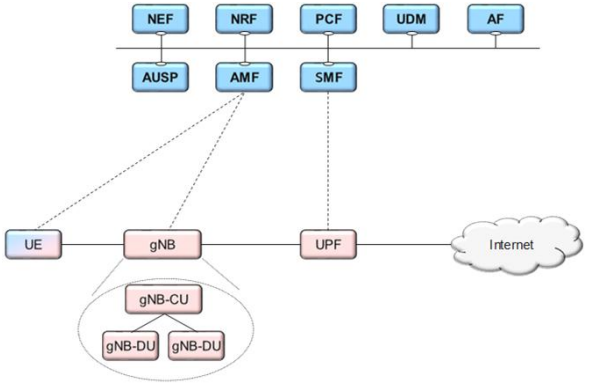


Network slicing



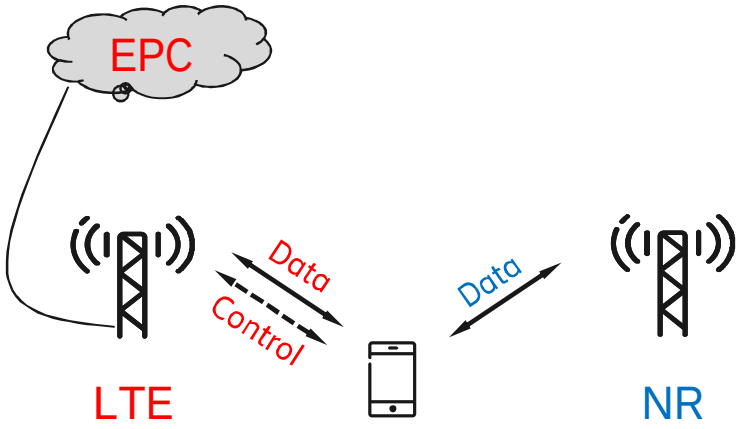
Modular architecture

DU/CU split, SBA

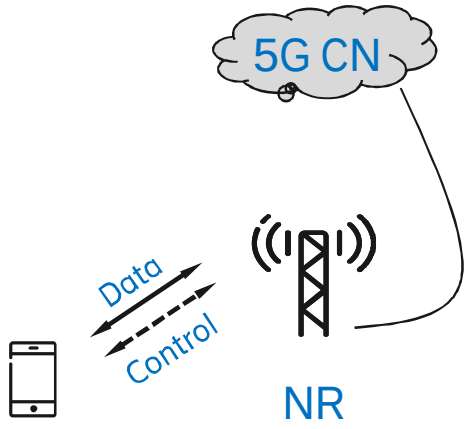


Architectural options

- Non-standalone NR
  - LTE handling initial access and mobility
  - NR is a “data rate booster”
  - Connects to EPC



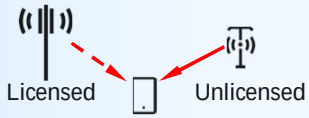
- Stand-alone NR
  - NR handles initial access and mobility
  - Connects to 5G CN



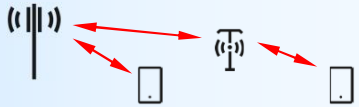
Some topics in NR Rel-16

TSN	time-sensitive networking
V2X	vehicle-to-anything
TRP	transmission-reception point
URLLC	ultra-reliable low latency communication
TDD	time-division duplex

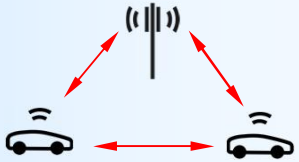
Unlicensed spectrum
LAA and stand-alone



Integrated Access Backhaul
NR for backhauling



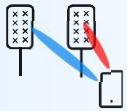
V2X
Sidelink, Uu enhancements, QoS, ...



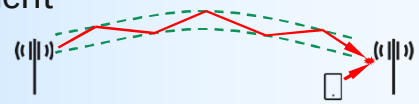
URLLC enhancements
Diversity, latency, ...

Industrial IoT
TSN support, time synchronization, ...

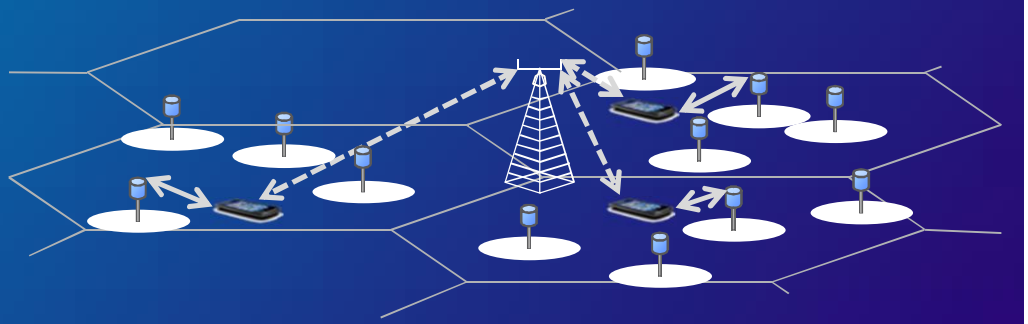
Multi-antenna enhancements
Beam management, CSI reporting, ...



Remote Interference Management
TDD, athmosperic ducts, ~300 km



NR Unlicensed Spectrum operations

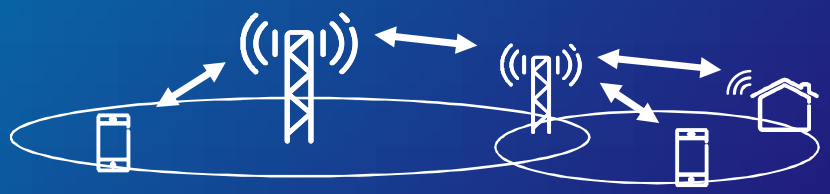


- Unlicensed spectrum considered by cellular operators as a complementary tool to augment their service offering
- Adapt initial/channel access, scheduling/HARQ, and mobility operations for unlicensed spectrum regulation & characteristics
  - Reuse existing NR as much as possible
- Existing bands and potentially new bands
  - Preferred band is 5/6 GHz
  - Coexistence study for new bands
- Support diverse deployment cases
  - Carrier aggregation NR + NR-U
  - Dual connectivity LTE/NR + NR-U
  - Standalone NR-U

Vehicle-to-everything (3GPP V2X Phase 3)

- Improved support for V2X services
  - LTE-V2X enables day-1 safety
  - NR-V2X is a complementary technology addressing new use cases (e.g. platooning, advanced driving, sensor sharing) and tighter requirements
- Study NR design for V2X
  - Targeting a wider range of frequencies (up to 52.6 GHz), with initial focus on FR1 frequencies.
  - Cellular (Uu) enhancements for high mobility scenarios and improved efficiency when delivering ITS traffic
  - Sensing-based resource allocation scheme mostly designed for aperiodic transmissions.
  - Some unicast/groupcast features such as link adaptation, power control, etc.
- Ensure optimal coexistence

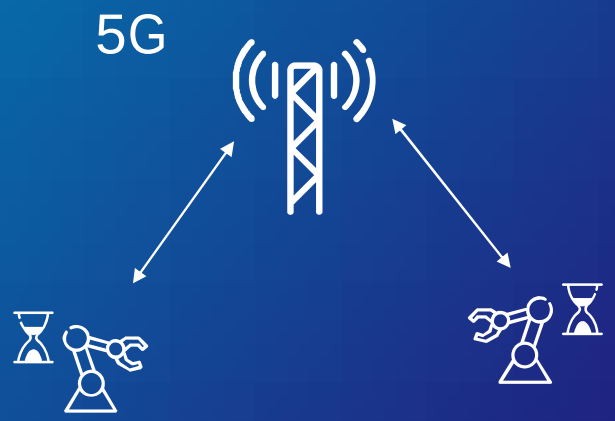
Integrated Access Backhaul



- Benefits:
  - Coverage extension for >6GHz
  - Easy and cost-efficient deployment
- Most relevant deployment scenarios
  - Outdoor, small-cell relay nodes (targeting FWA & eMBB)
  - Fixed relays, but forward compatible to nomadic/mobile
  - Limited number of hops (>=2)
  - Star / tree deployment (no mesh)
  - Inband and outband relaying using >6GHz
  - IAB transparent to UEs (Rel-15 backwards-compatible)
  - Support SA and NSA operations

NR URLLC

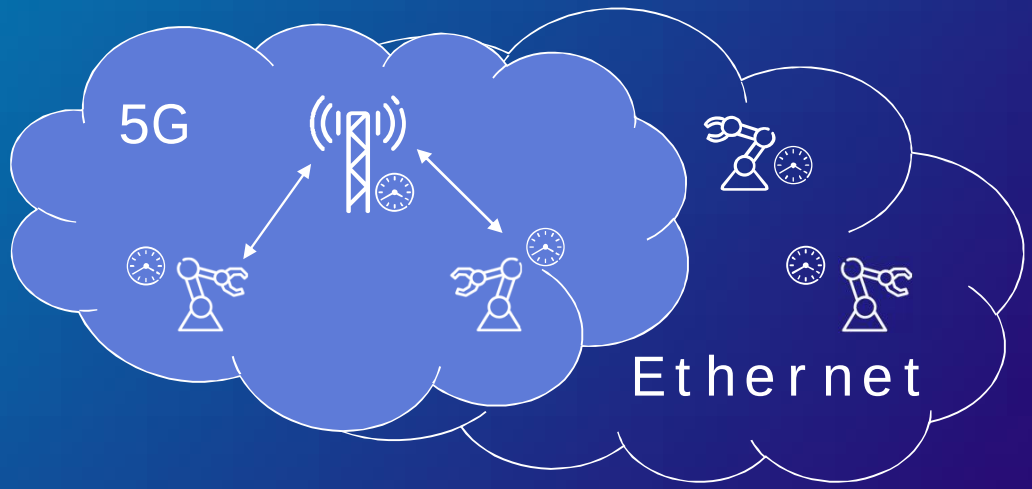
RAN1-led, L1 focused



- Improved reliability (connectivity and operations) and latency
  - Enhance radio channel reliability
  - Decrease end-to-end latency via faster access
- Improve full automation and flexibility
  - Scheduling enhancements

NR Industrial IoT

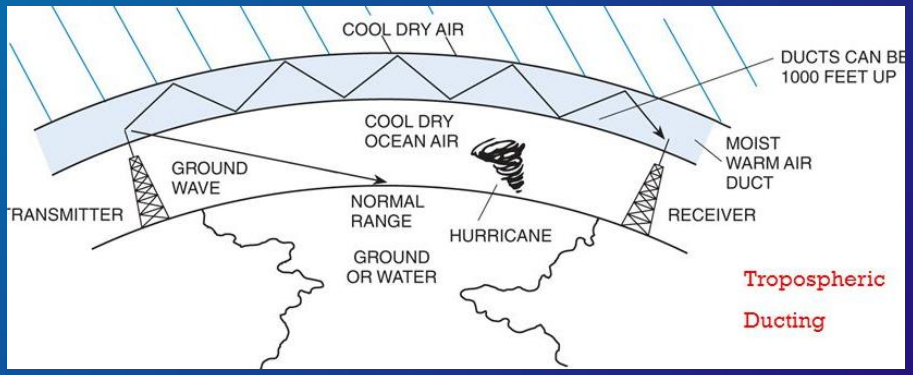
Ran2-led, Higher layer focused



URLLC use cases in TS 22.261 and TS 22.804

- Industry-grade NR for Industrial IoT
  - Ethernet and IEEE 802.1 (e.g. TSN) features often the basis in such networks. 5GC introduces Ethernet-type PDU Session.
    - Optimizations for Ethernet PDU Sessions
      - Header compression
      - Possible QoS enhancements
  - Enabling time-synchronized operations of devices (e.g., time synchronized UEs to enable synchronized operating on joint tasks)
  - Support for redundant PDU sessions
    - aligned with SA2
  - Study and define mid-tier NR UE (no new design)

NR Remote Interference Management and Cross-Link Interference

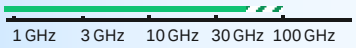


- RIM
  - BS-to-BS interference over large distance (up to 300 km)
  - Due to tropospheric ducting, which occurs in certain weather conditions
  - Static and dynamic RIM
  - Frameworks for centralized and distributed RIM
- CLI
  - Dynamic TDD

Possible topics in Rel-17

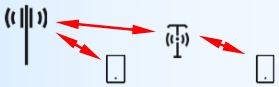
Continuation of Rel-16 – examples

- Above 52.6 GHz



- Unlicensed, 60 GHz

- IAB enhancements



- Sidelink

- Non-terrestrial access

New topics – examples

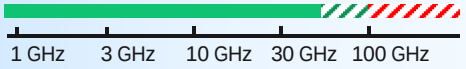
- Drone enhancements
- Multicast/broadcast
- NR MTC for industrial sensors
- Reduced complexity/power consumption

What about the longer time perspective?

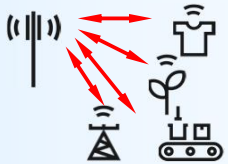
Longer-term evolution

Some examples

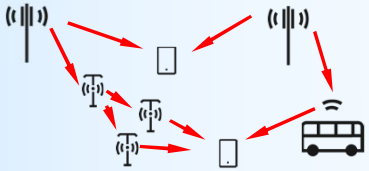
Beyond 100 GHz



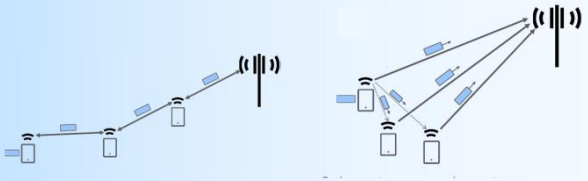
Massive IoT



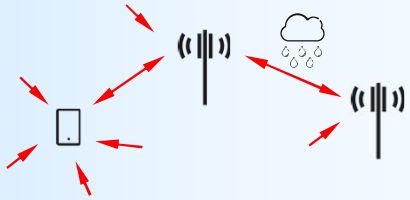
Flexible network topologies



Device cooperation



Cellular as a sensor



Machine Learning – Artificial Intelligence

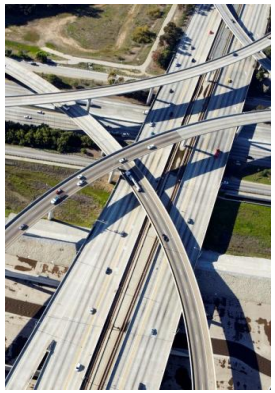
5G – Beyond Mobile Broadband

Broadband experience everywhere anytime

Mass market personalized media and gaming

Meters, sensors, “Massive MTC”

Remote controlled machines



Smart Transport Infrastructure and vehicles

Human / machines interaction

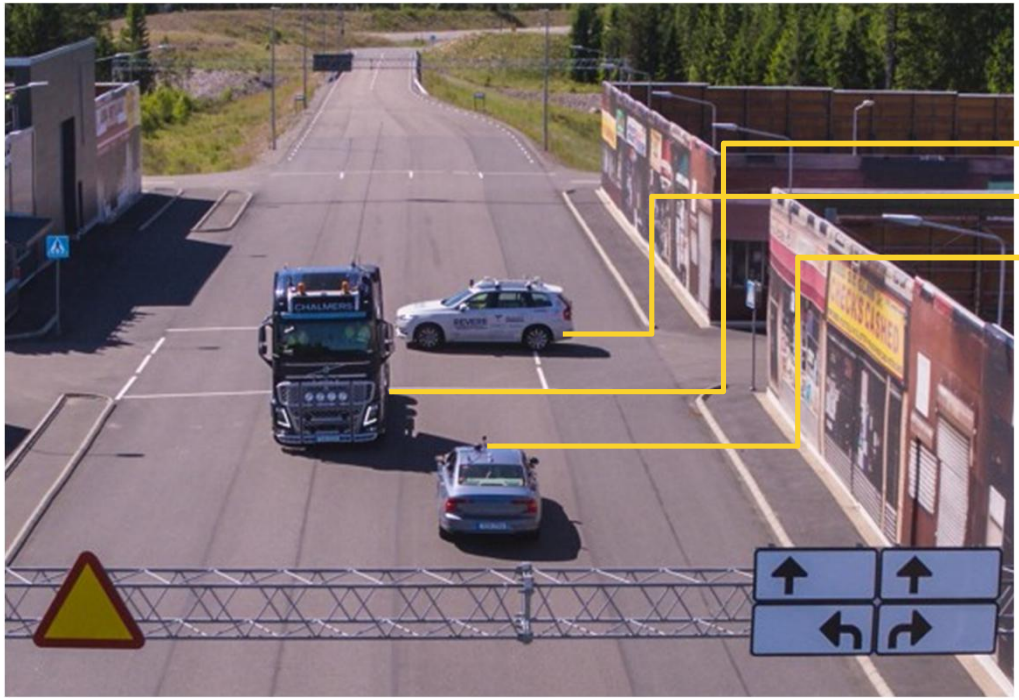
And much more!

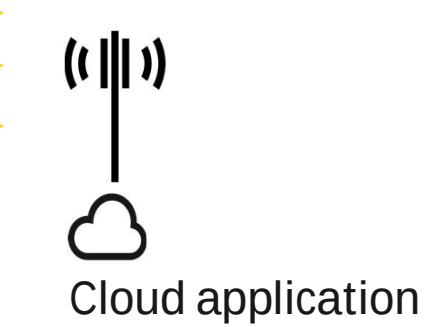
New opportunities and flexibility for the unforeseen

Use case
– Intersection control

Main requirements
- Latency
- Reliability
- Connected devices

Demonstration at AstaZero (test facility Sweden)
- Connecting two XC-90 cars and one Volvo truck
- Coordination application running in cloud

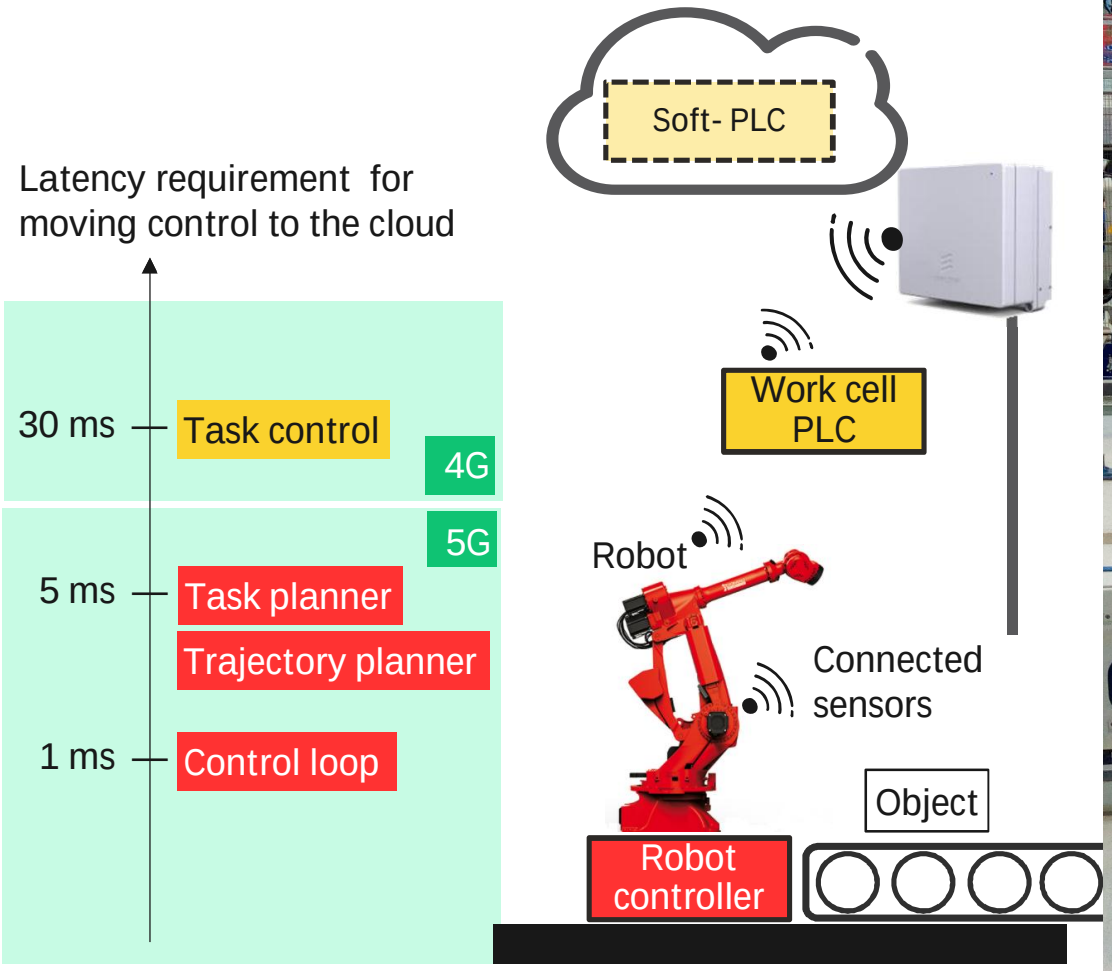




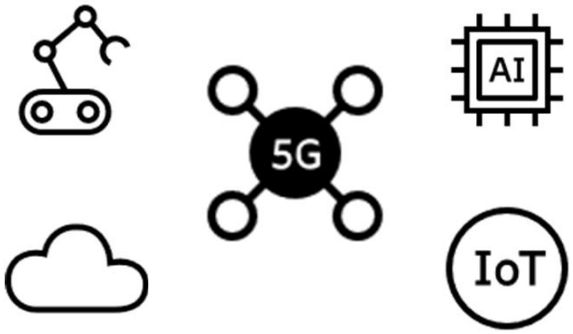
Video available on Youtube!
(search: Ericsson+AstaZero)

Cloud based control logic

Latency requirement for moving control to the cloud



A fully 5G connected manufacturing plant



- Digital twins and real-time control loops in edge cloud
- Data management & machine learning to plan and order maintenance and workflow
- AR/VR to visualize workflow & machine status
- Indoor positioning & edge cloud for automatic control of AGVs in factory
- With everything automated, using AR/VR for monitoring and issuing work orders, lights are no longer necessary

Summary

- 5G New Radio has been standardized in Release 15 and deployments are ongoing
- … but this is only the beginning

- The common 3GPP approach is ongoing with continuous improvements in every release

- Release 16 is in progress, with significant NR improvements including
  - Integrated Access and Backhauling
  - Unlicensed spectrum
  - Improved Industrial IoT
  - Sidelink communication

- Preparations towards Release 17 are on-going