5G Primer

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Bandwagon or pioneer?

Agenda

- Driving towards more mobile connectivity

- Just a reminder EE's 4G Network

- What is 5G?

- Use Cases

- 5G Architecture

- Standards

- 5G Radio

- Convergence

- Conclusions

# Today's users today are....

St. Peter's Square   2005

2013

EE: The Biggest and Best Network
The world's fastest 4G rollout

- The UK's first 4G network

  - 4G to around 95%+ population coverage, equal to more than 75% of the UK geography

  - Upgrading 100 4G sites a week

  - 95% geographic coverage by 2020

- The UK's biggest 3G network

  - 73% geographic 3G coverage

- Invested more than £500m a year on our network since 2012]

- 50% faster than the rest and continuing to invest-

  - Now deploying 4x4 MIMO and CA
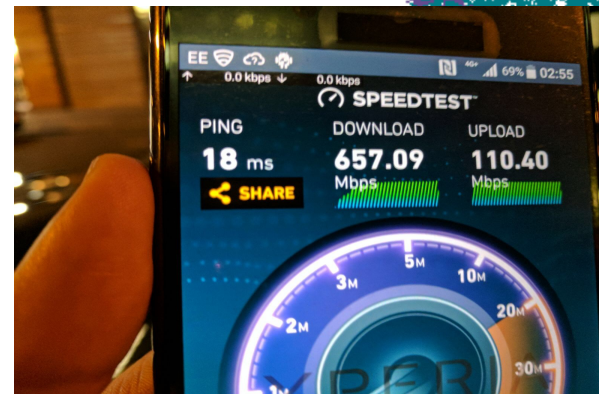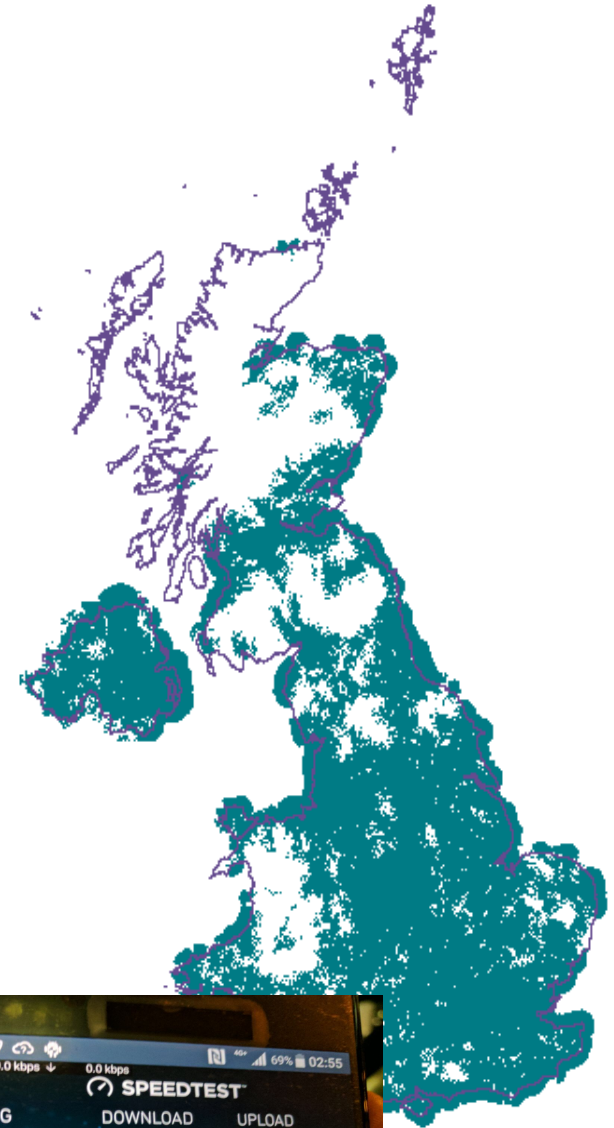
What is 5G?

Enhanced Mobile Broadband – UHD Video, Virtual/Assisted Reality, Interactive gaming, Tactile Internet, Fixed Wireless Access

Mission Critical Machine Type Comms – self/assisted driving, traffic safety and control, industry automation, remote surgery

Massive Machine Type Comms – IoT, Smart Home/Building/Factory/Energy, Smart Agriculture, Logistics, Asset Tracking
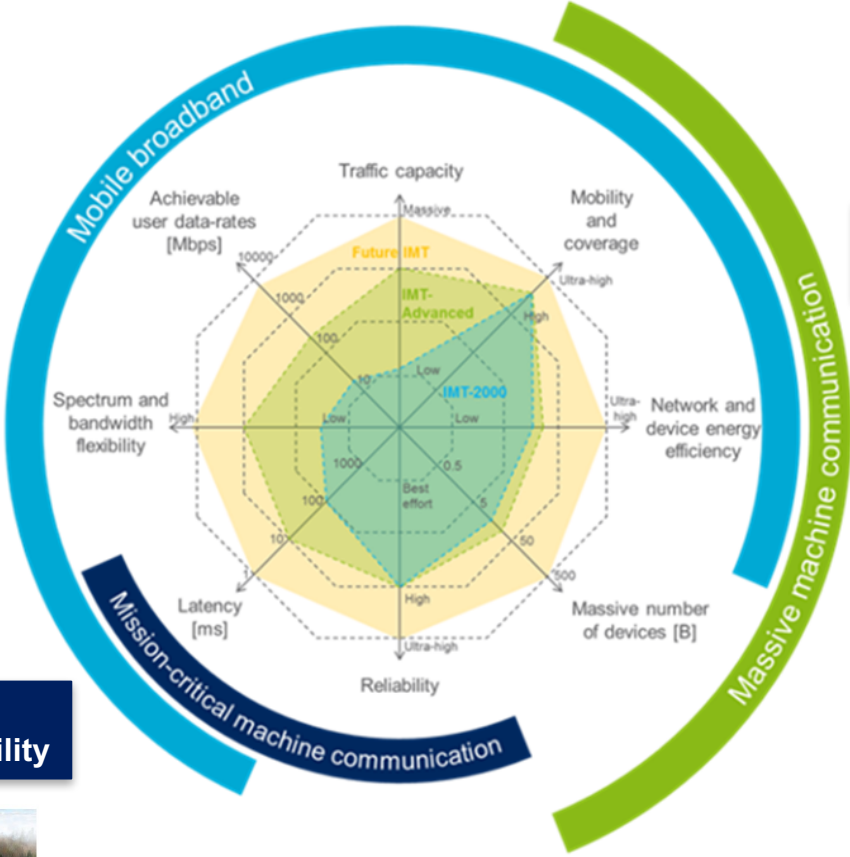

Logistics/Tracking   Smart Agriculture   Smart Home/Building/Factory/Energy

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5G performance requirements

10 Gbps peak data rate
1 Gbps average data rate

1m connections /Km2
10 year battery

1msec latency
Ultra high reliability/availability

5G Platform

5G will be a platform enabling business opportunities - integration and enablement of new ecosystems, network "slices", analytics

5G will be a programmable system, enabling interworking and seamless mobility, using many wireless cells types, building on the 4G network

SC
AP
4G
WiFi/Fixed
NB-IoT
5G-NR Wide Area
5G-NR mmWave

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Much more that just next generation mobile...
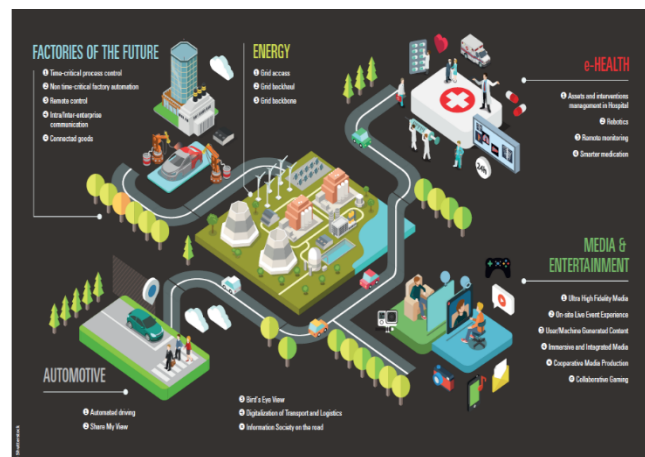
Transport
Healthcare
Utilities
Agriculture
Aviation
Education Entertainment
Factory Automation
etc

5G:

- has widely varying use cases
- has widely varying performance requirements
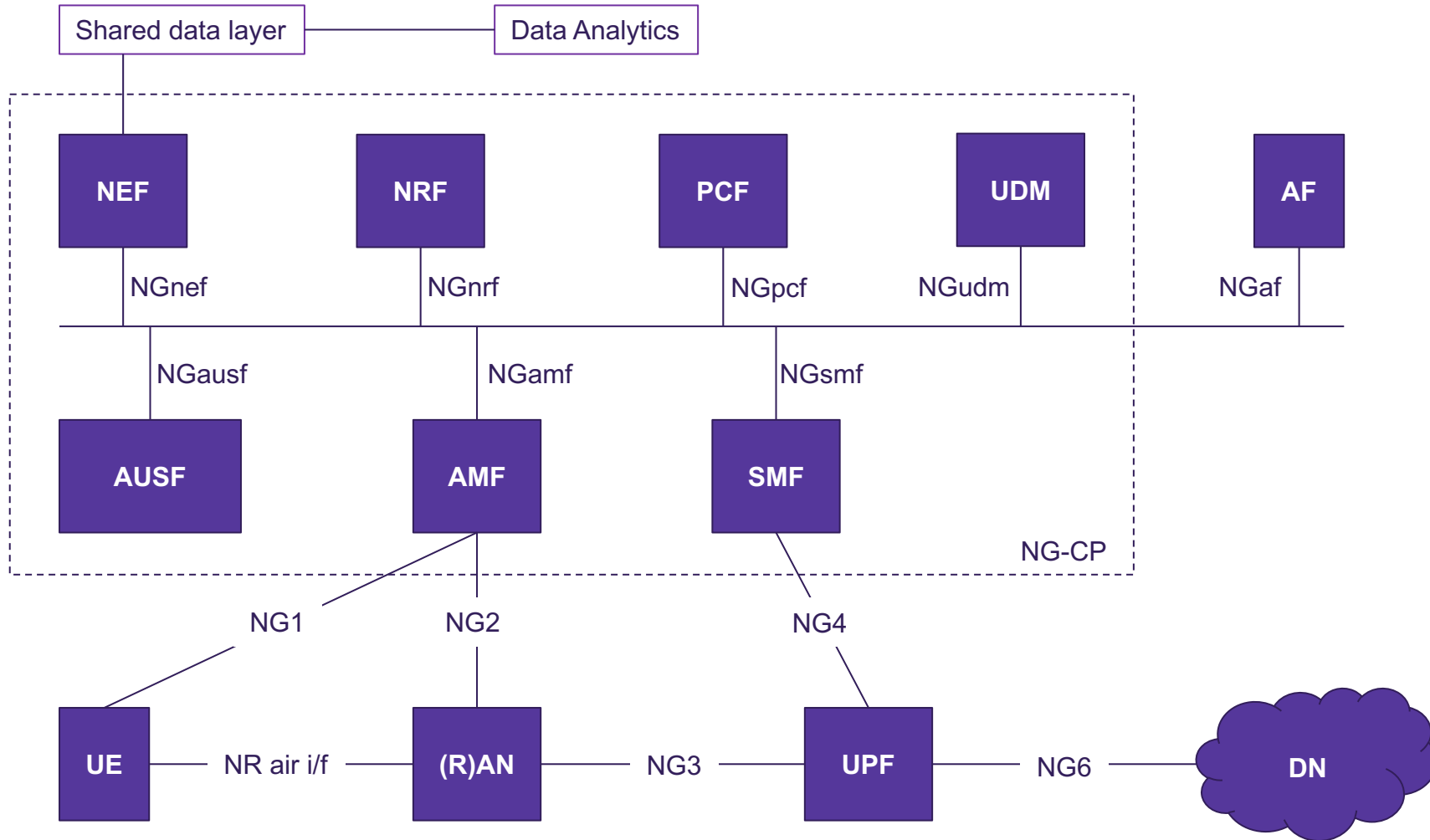- is not only about connecting *people*, but also about connecting *things*

No single technology will satisfy all of these requirements

These requirements will not all be met at the same point in time

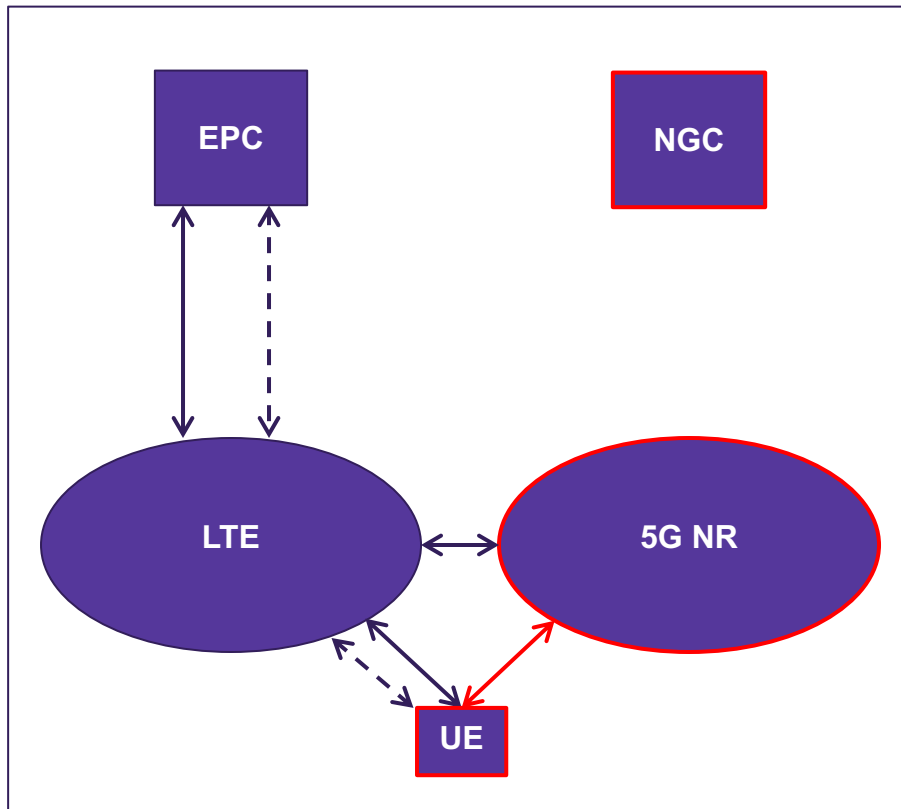BT

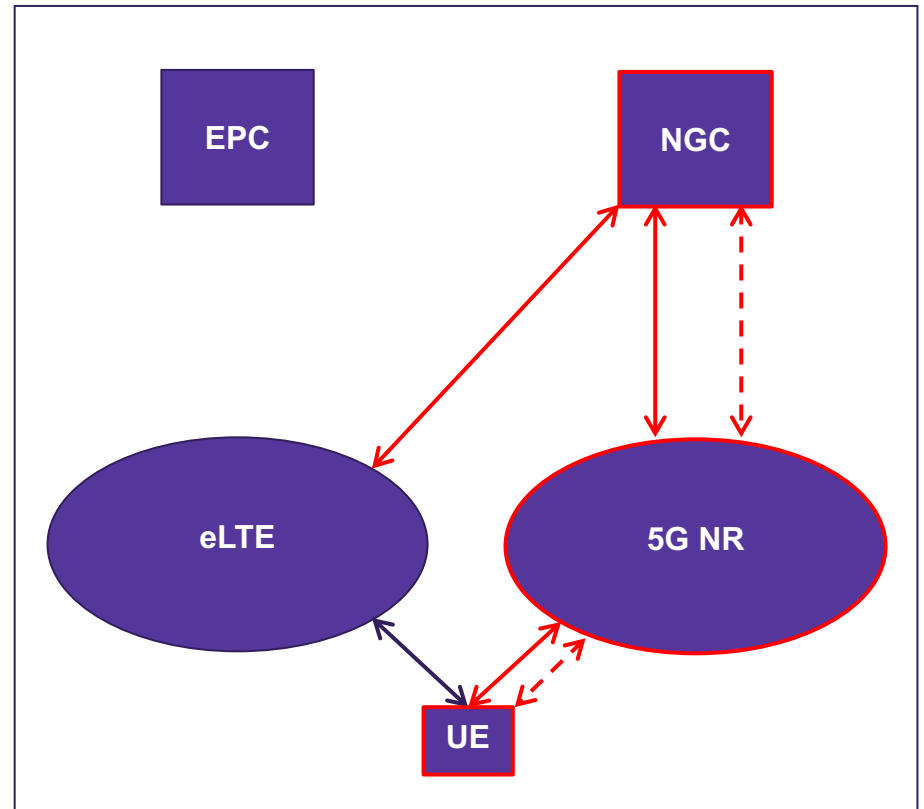# Internet of Skills – 5G Use Case – BT/Ericsson/Kings
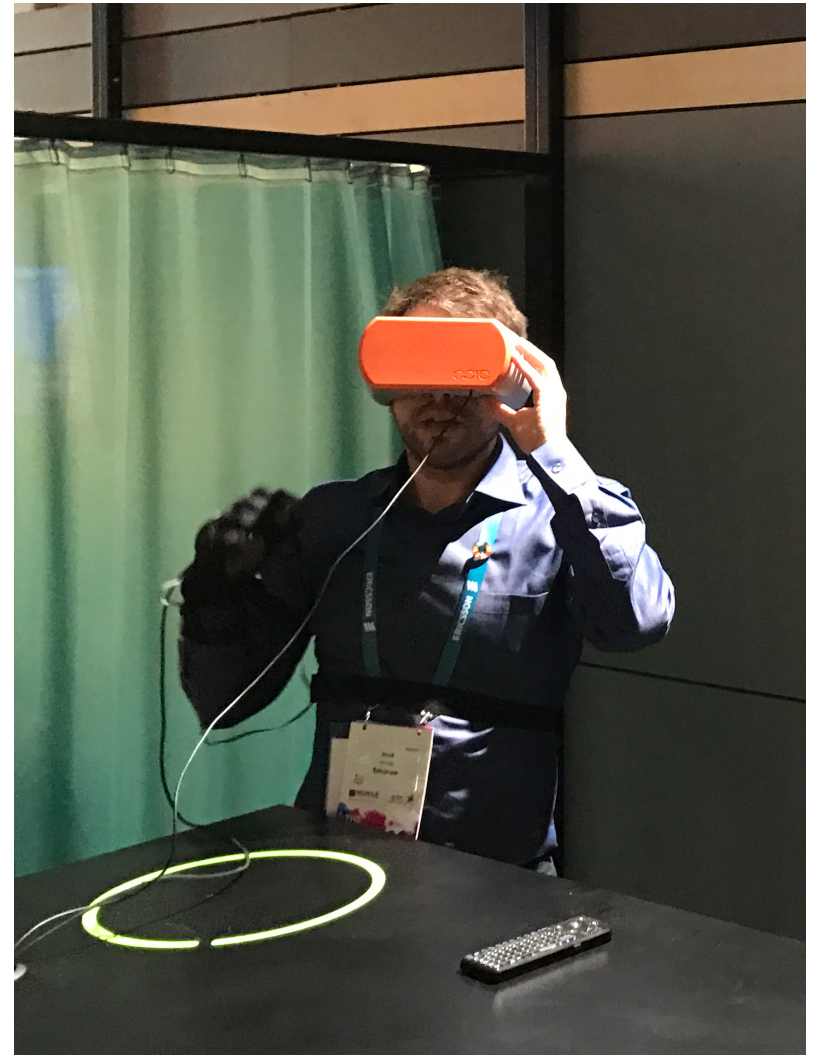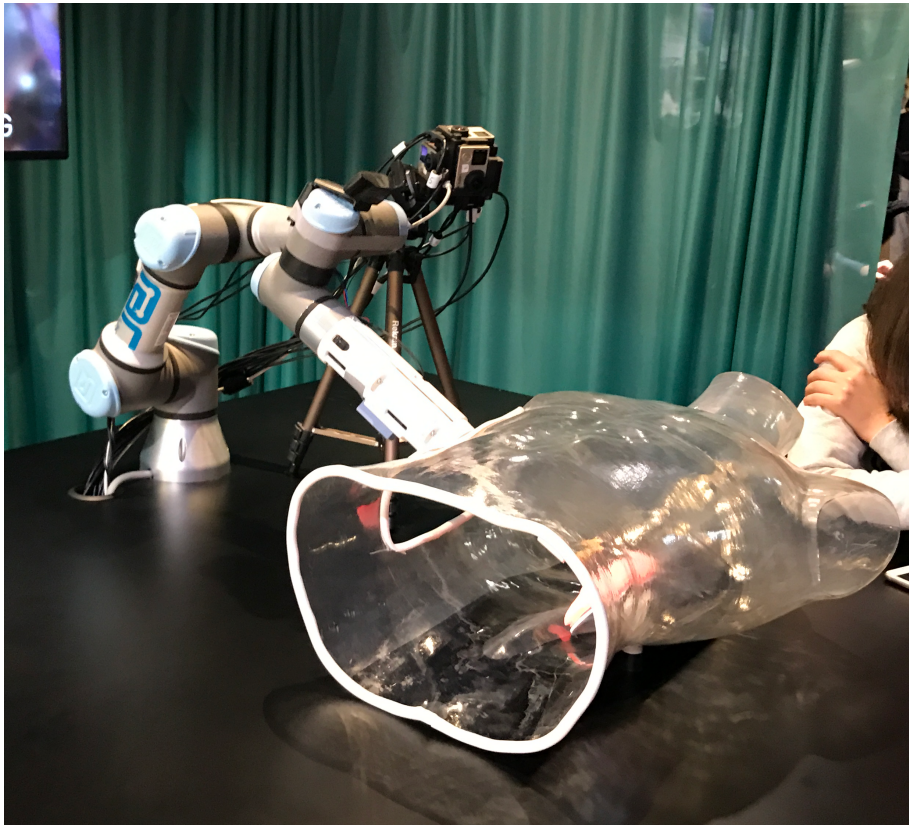
5G Core Service Based Architecture

5G Radio Architecture

Early Release based on 4G EPC

Full 5G with new Core

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Network Slicing

## Rapid deployment of new services

- Need to deploy new services with no disruption to existing ones

- Agility is required to compete and meet market demand

- NFV and SDN enable orchestration across slices

- End goal is fully automated deployment of new network slices

Support for different operational models

- Different SLAs (e.g. security, reliability etc.) may require isolation between different slices

- Slicing can be done on a per service-type or even for individual customers

Conflicting functional requirements

- Some functional requirements may be mutually exclusive, e.g. high data throughput versus low latency or highly-mobile versus fixed access.

- Optimisation of each slice for the specific functionality required (e.g. non-mobile slice)
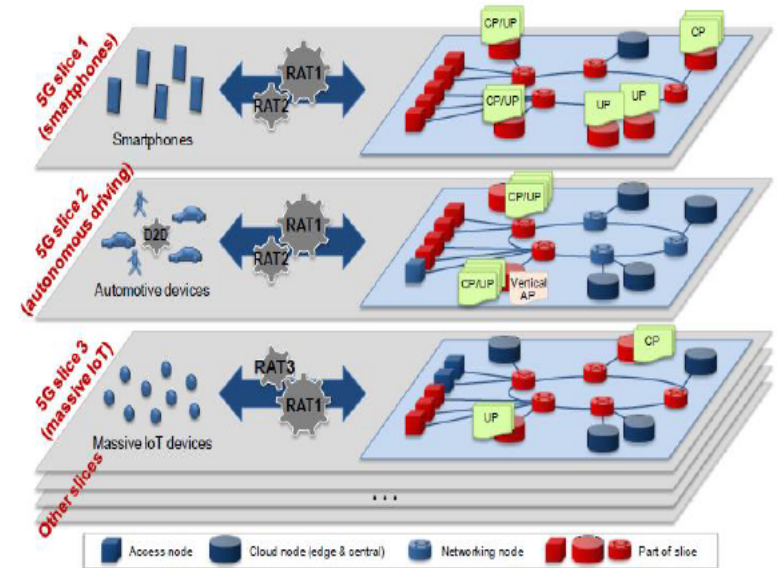
Source: NGMN 5G white paper

5G-NR – Revolution or Evolution

Massive IoT

- Low complexity narrowband
- Low power modes for deep sleep
- Efficient signaling
- Grant-free uplink transmissions
- Optimized link budget
- Managed multi-hop mesh

5G NR

Mission-Critical Control

- Low-latency with bounded delay
- Efficient multiplexing with nominal traffic
- Grant-free uplink transmissions
- Simultaneous redundant links
- Reliable device-to-device links
- Optimized PHY/pilot/HARQ

Enhanced Mobile Broadband

- Wider bandwidths
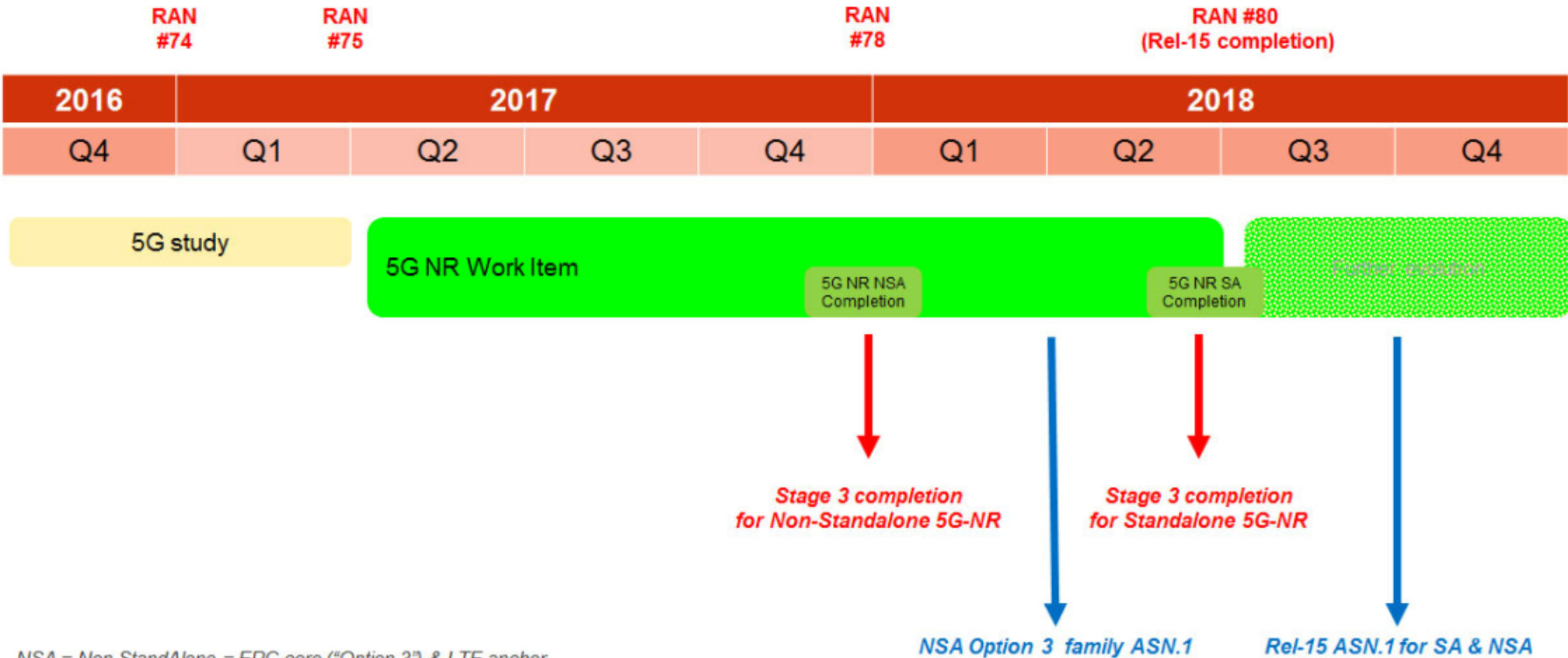- Mobilizing mmWave
- Shared spectrum
- Device-centric mobility

- Dynamic, low-latency TDD/FDD
- Massive MIMO
- Advanced channel coding
- Native HetNet and multicast support

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Standards Timeline

5G-NR eMBB workplan

RAN #74   RAN #75   RAN #78   RAN #80 (Rel-15 completion)

2016	2017				2018			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

5G study

5G NR Work Item

5G NR NSA Completion

5G NR SA Completion

Stage 3 completion for Non-Standalone 5G-NR

Stage 3 completion for Standalone 5G-NR

NSA Option 3 family ASN.1

Rel-15 ASN.1 for SA & NSA

NSA = Non StandAlone = EPC core ("Option 3") & LTE anchor
SA = StandAlone

5G Main Standards Activities

5G ARCHITECTURE

- Overall Service-Oriented Architecture
- Network Slicing
- Self Optimised Networks with Self Healing
- Convergence

5G RADIO

- Radio Features: MIMO, Beamforming, Mini-Slots
- Self Backhaul
- Small Cells
- Centralised/Distributed Functional Split

5G PHASING

- Early networks with 4G Core and 5G Radio
- How to migrate to full 5G including handset issues
- Virtualised 4G Core inside 5G

5G SECURITY

- Device Certificates
- Mutual Authentication
- Key Exchange Protocol
- Protect Long Term Identity using PKI

Ofcom and RSPG (Radio Spectrum Policy Group) has identified three pioneer bands for 5G in Europe
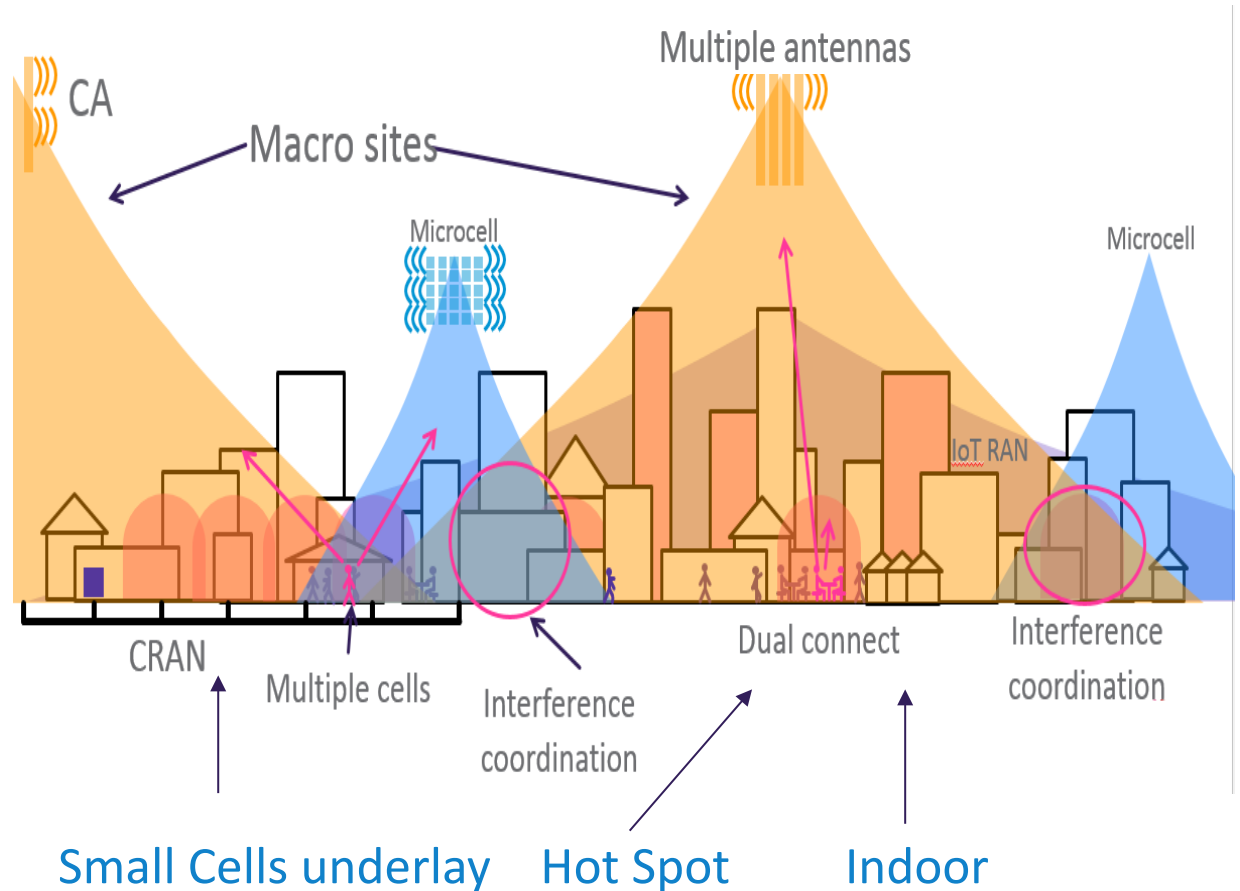
RSPG's pioneer bands:

- 700 MHz band – to provide a coverage layer
  - 2 x 30 MHz + 20 MHz centre gap – SDL – Likely auction: 2019/2020
- 3.4 – 3.8 GHz band – to provide a large amount of contiguous spectrum for high-data rate and low-latency services and a capacity solution in congested areas
  - 150 MHz in the 3.4 – 3.6 GHz band in 2017, via auction
- 26 GHz band – to provide "fibre-like" data rates and very low latencies at short distance, as a capacity solution in very congested hotspots
  - 24.25 – 27.5 GHz – date tbd, likely auction post WRC2019

[Note: Existing bands could be refarmed and more bands are likely in the future...]

5G Radio Access – Implementation Scenario

Likely scenario for 5G deployment will be to provide:

- NR deployed in sub 6GHz bands for wide area '5G' coverage

- Ultra-high speed in mmWave bands

- Initial IoT support via current NB-IoT

  - 5G IoT expected later

CA

Multiple antennas

Macro sites

Microcell

Microcell

IoT RAN

CRAN

Multiple cells

Interference coordination

Dual connect

Interference coordination

Small Cells underlay   **Hot Spot**   **Indoor**

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Massive MIMO

Increase capacity and peak rates through high order MIMO and beam forming

Key technology for mmWave and increasing capacity using existing mobile spectrum

Undertaken field trials with University of Bristol
- Indoor environment mimicking a stadium like deployment
- Outdoor with mobile devices (30mph)

Spectrum efficiency gains are substantial
Current deployed LTE in the order of 5bps/Hz

Proof of concept achieved 100bps/Hz

(24 UE's 16QAM 3.4GHz 20MHz channel)
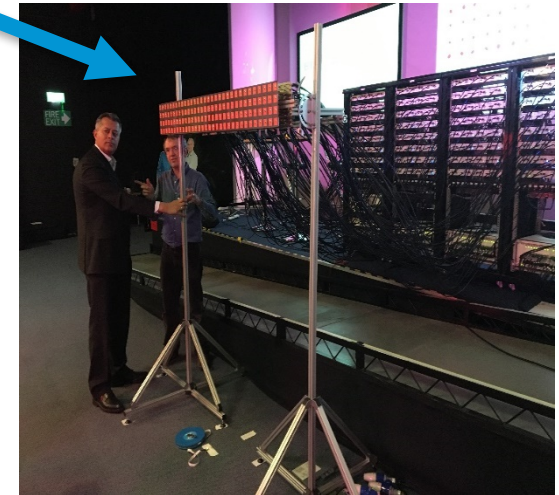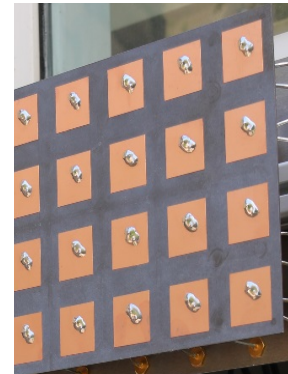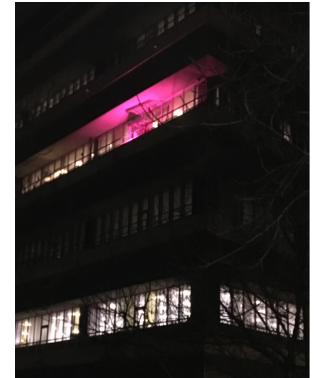
Convergence & 5G

Driving economics and performance across the network to provide seamless, highly-secure 'any device' services to our customers and utilising the best of the underlying platforms and infrastructure to provide an enhanced user experience:

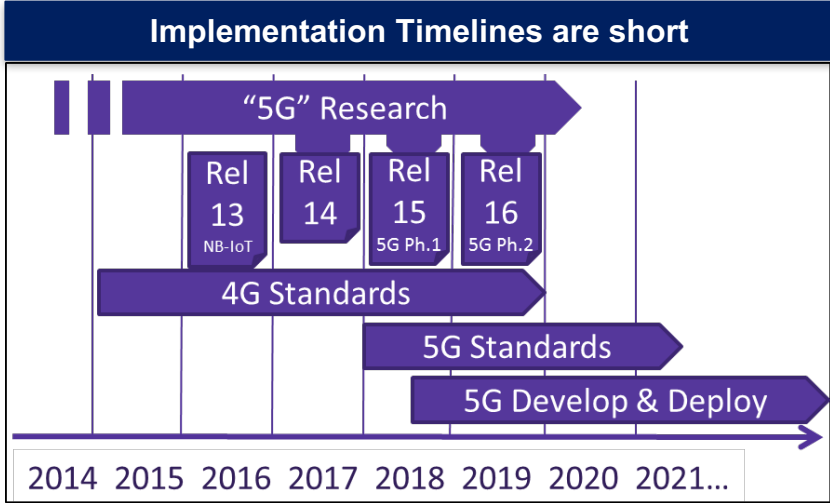| 1 Products & Services	2 Channels to Market	3 Customer Service	4 Platform	5 Network
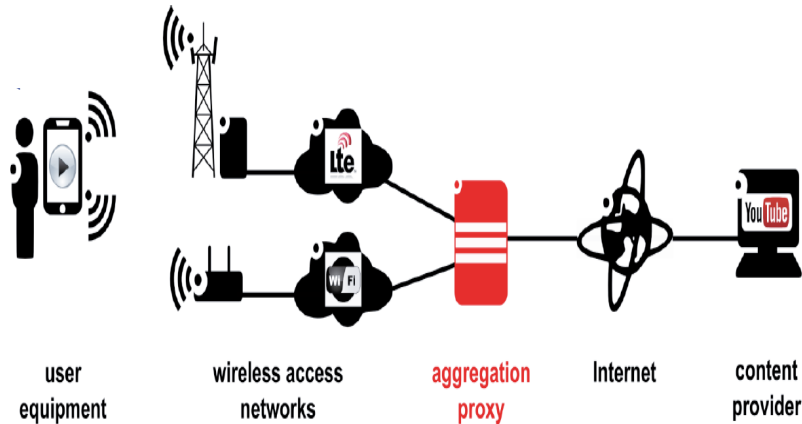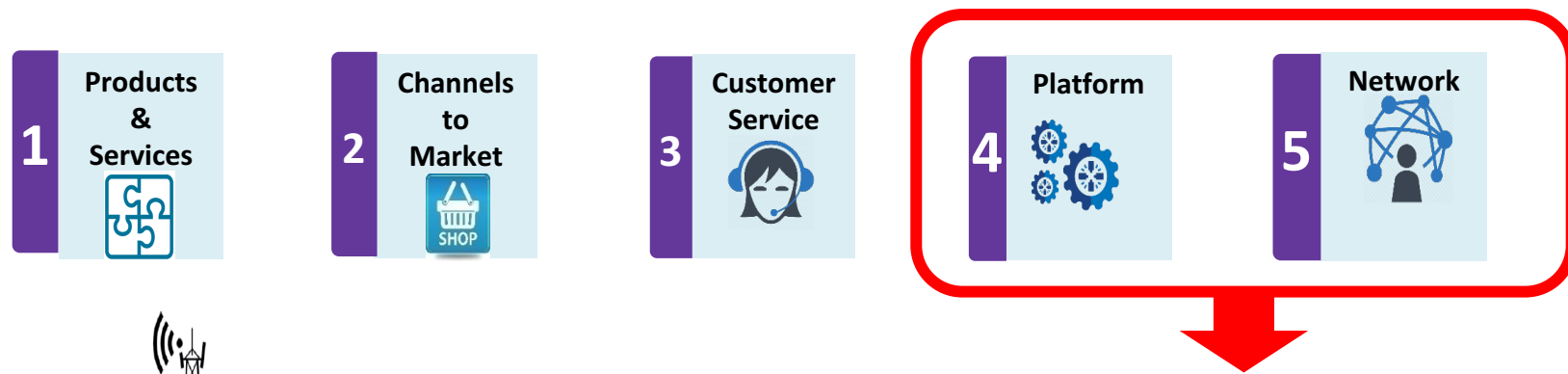
Example: Multi-connectivity
5G will form a "capacity layer" alongside 4G delivering ubiquitous coverage. Multi-connectivity will initially link 4 & 5G but may also combine 5G with other radio technologies (e.g. Wi-Fi) and fixed

user equipment | wireless access networks | aggregation proxy | Internet | content provider

We are driving to align control and support systems for fixed and mobile

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Summary

5G brings many advances but focus needed

10 Gbps peak data rate
1 Gbps average data rate

1msec latency
Ultra high reliability/availability

1m connections /Km2
10 year battery

EE 4G is already very fast

Implementation Timelines are short

"5G" Research

Rel 13 NB-IoT | Rel 14 | Rel 15 5G Ph.1 | Rel 16 5G Ph.2

4G Standards

5G Standards

5G Develop & Deploy

2014 2015 2016 2017 2018 2019 2020 2021...

BT is playing its part in driving 5G

Lets continue to be pioneers!

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Any questions?

THANK YOU