5G DEVELOPMENTS & OUTLOOK

Adrian Pais | CWTe 2019 Research Retreat | 9th October 2019
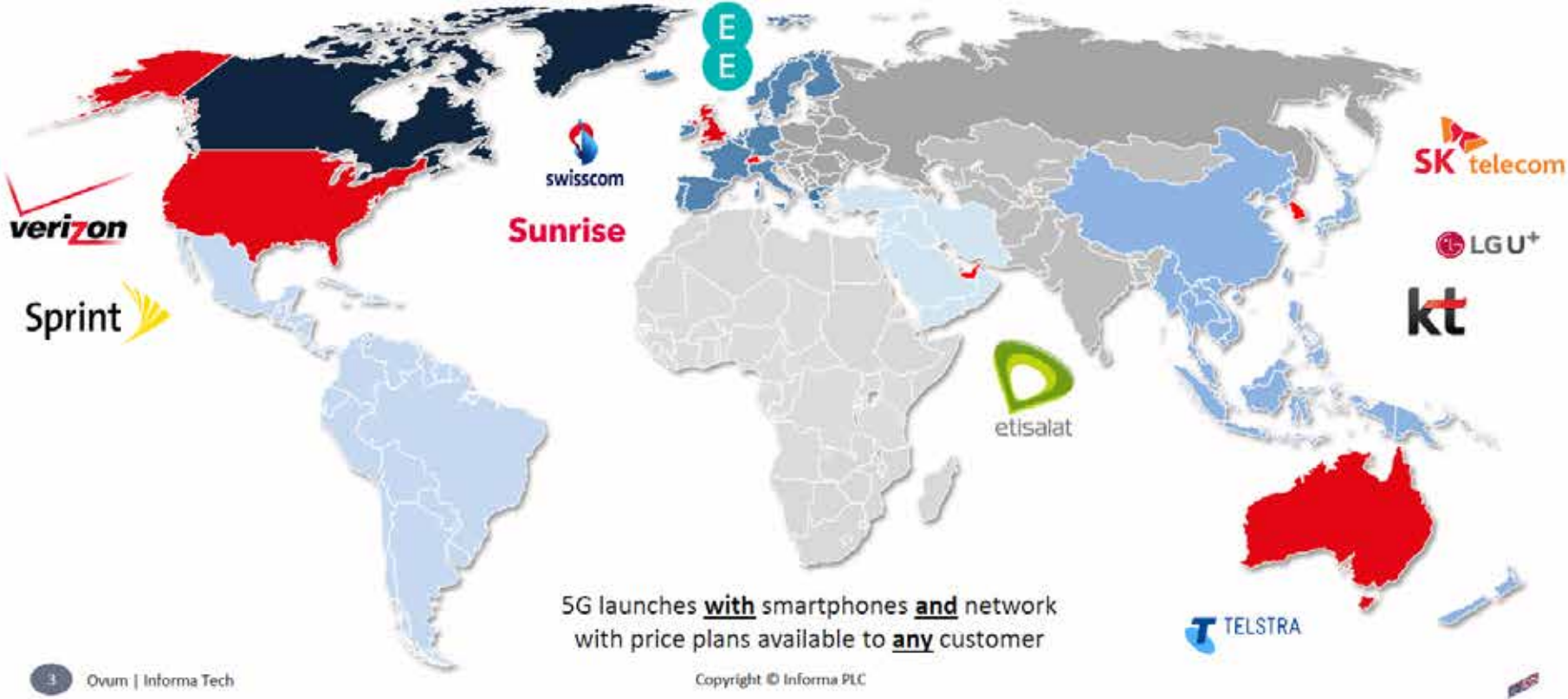
TNO innovation for life

OUTLINE

5G industry developments & outlook

5G trials and use cases: focus on 5Groningen

FIRST COMMERCIAL 5G LAUNCHES IN 2019

verizon

Sprint

swisscom

Sunrise

EE

SK telecom

LG U+

kt

etisalat

TELSTRA

5G launches **with** smartphones **and** network with price plans available to **any** customer

Ovum | Informa Tech

Copyright © Informa PLC

3

Source: Informa

FIRST 5G SMARTPHONES AVAILABLE

OPPO Reno 5G
1st 5G Smartphone in Europe, on sale since 1st of May

LG V50 ThinQ
on sale since 24th of May

Samsung Galaxy S10 5G
On sale from 14th of June
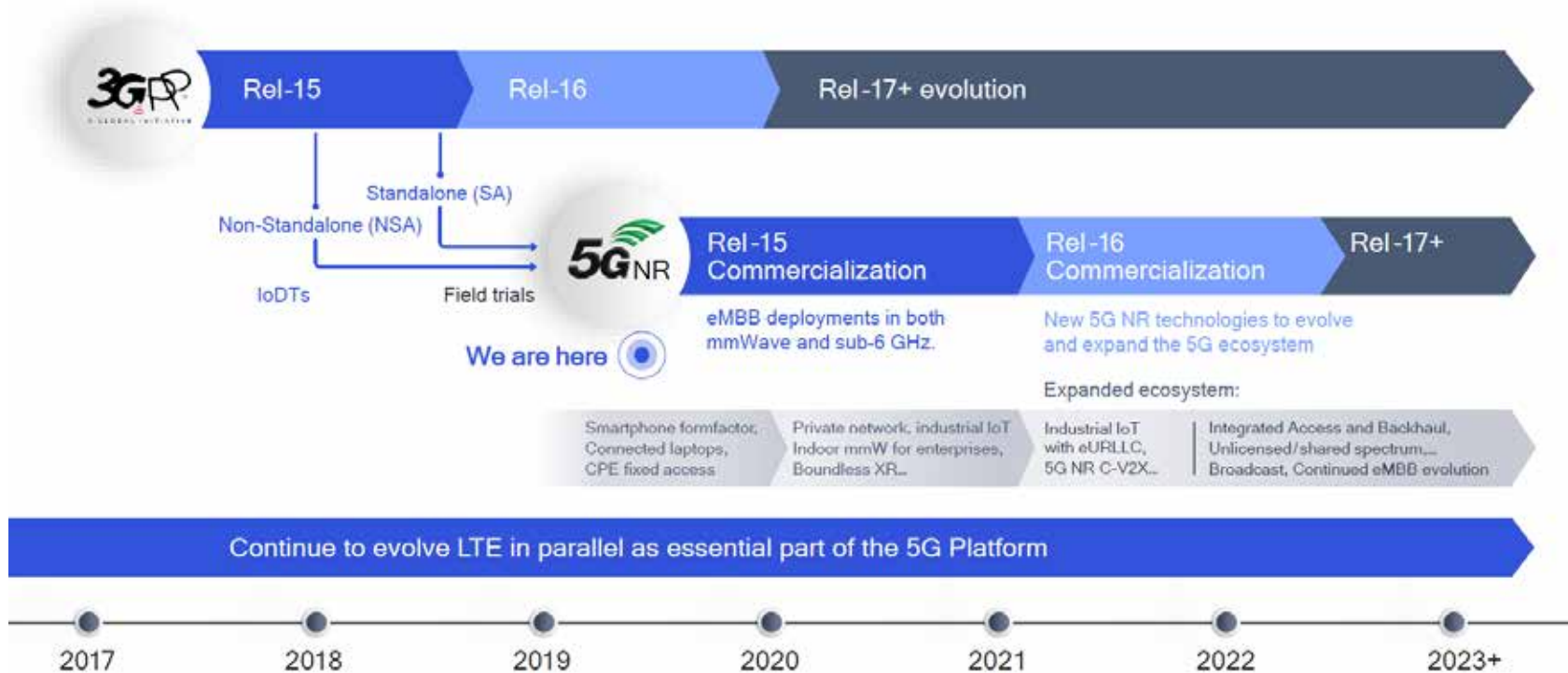
Source: Swisscom

NEARLY 30 VENDORS WITH 5G DEVICES IN MARKET

Laptops/PC — Smartphones — HotSpots — CPE — Wearables — IoT

Source: Informa

5G FIELD TESTS – PEAK DOWNLOAD SPEEDS

	Peak download speed (Speedtest.net)	Location	5G technology	Phone	Test date
AT&T	1.8 Gbps	Los Angeles (Warner Bros. Studio)	mmWave	Galaxy S10 5G	June 22, 2019
Verizon	1.3 Gbps	Chicago	mmWave	Galaxy S10 5G	May 16, 2019
SK Telecom	618 Mbps	Seoul	Sub-6GHz	Galaxy S10 5G	June 27, 2019
T-Mobile	583 Mbps	New York	mmWave	Galaxy S10 5G	June 28, 2019
Telstra	489 Mbps	Sydney	Sub-6GHz	Oppo Reno 5G	June 20, 2019
Telstra	485 Mbps	Sydney	Sub-6GHz	LG V50	June 14, 2019
Sprint	484 Mbps	Dallas	Sub-6GHz	LG V50	May 30, 2019
EE	460 Mbps	London	Sub-6GHz	OnePlus 7 Pro 5G	June 15, 2019

Source: C-NET

INITIAL 5G ROLLOUTS ARE OPERATOR LED, FOCUSING ON ENHANCED MOBILE BROADBAND …

Source: Qualcomm

… OPPORTUNITIES FOR VERTICALS WILL FOLLOW

Enhanced Mobile Broadband
Capacity Enhancement

- Gigabytes in a second
- 3D video - 4K screens
- Work & play in the cloud
- Augmented reality
- Industrial & vehicular automation
- Mission critical broadband
- Self driving car

Smart city cameras

Voice

Sensor NW

Massive IoT
Massive Connectivity

Low Latency
Ultra-High Reliability & Low Latency

Source: Qorvo Inc., from ITU-R
IMT 2020 requirements

8
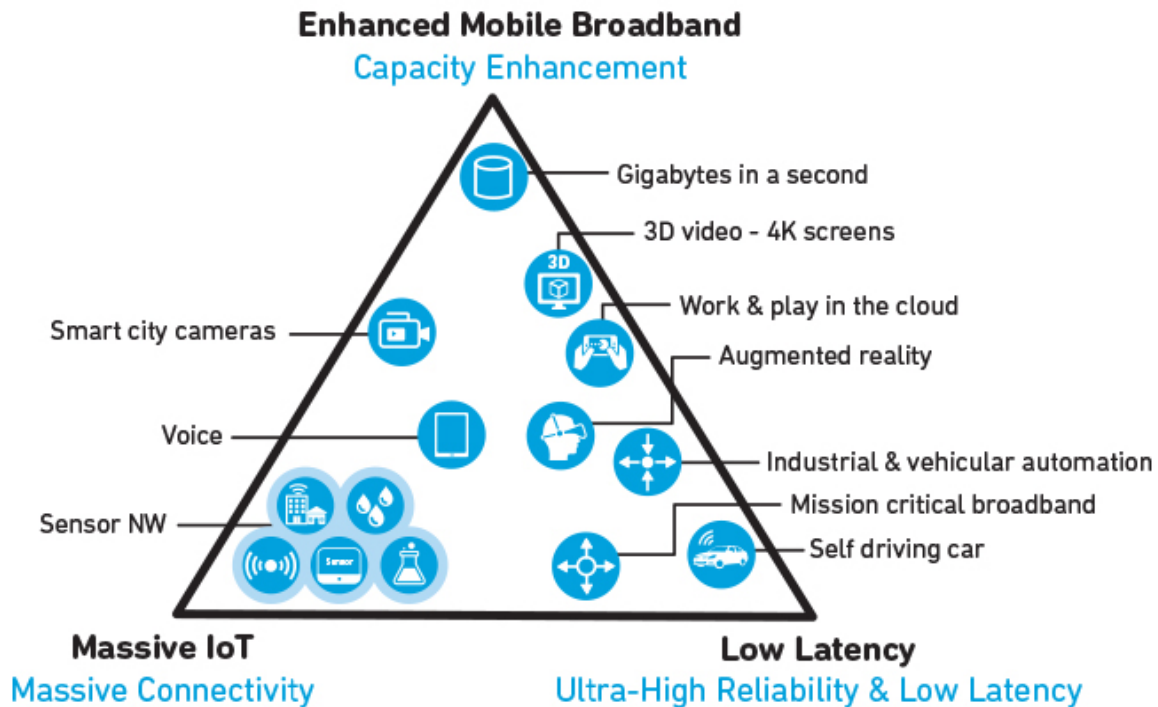
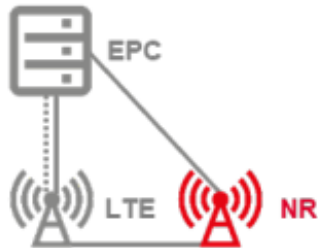# SEVERAL ARCHITECTURAL OPTIONS FOR 5G
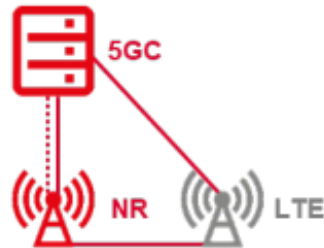
Standalone LTE under EPC (option 1)

Standalone NR under 5GC (option 2).

Standalone LTE under 5GC (option 5)

Non-standalone LTE and NR under EPC (option 3)

Non-standalone NR and LTE under 5GC (option 4).

Non-standalone LTE and NR under 5GC (option 7)

TNO innovation for life

SEVERAL ARCHITECTURAL OPTIONS FOR 5G

Commercial deployments expected in 2020

First commercial deployments in 2019

EPC
LTE
Standalone LTE under EPC (option 1)

5GC
NR
Standalone NR under 5GC (option 2).

5GC
LTE
Standalone LTE under 5GC (option 5)

EPC
LTE   NR
Non-standalone LTE and NR under EPC (option 3)

5GC
NR   LTE
Non-standalone NR and LTE under 5GC (option 4).

5GC
LTE   NR
Non-standalone LTE and NR under 5GC (option 7)

TNO *innovation for life*
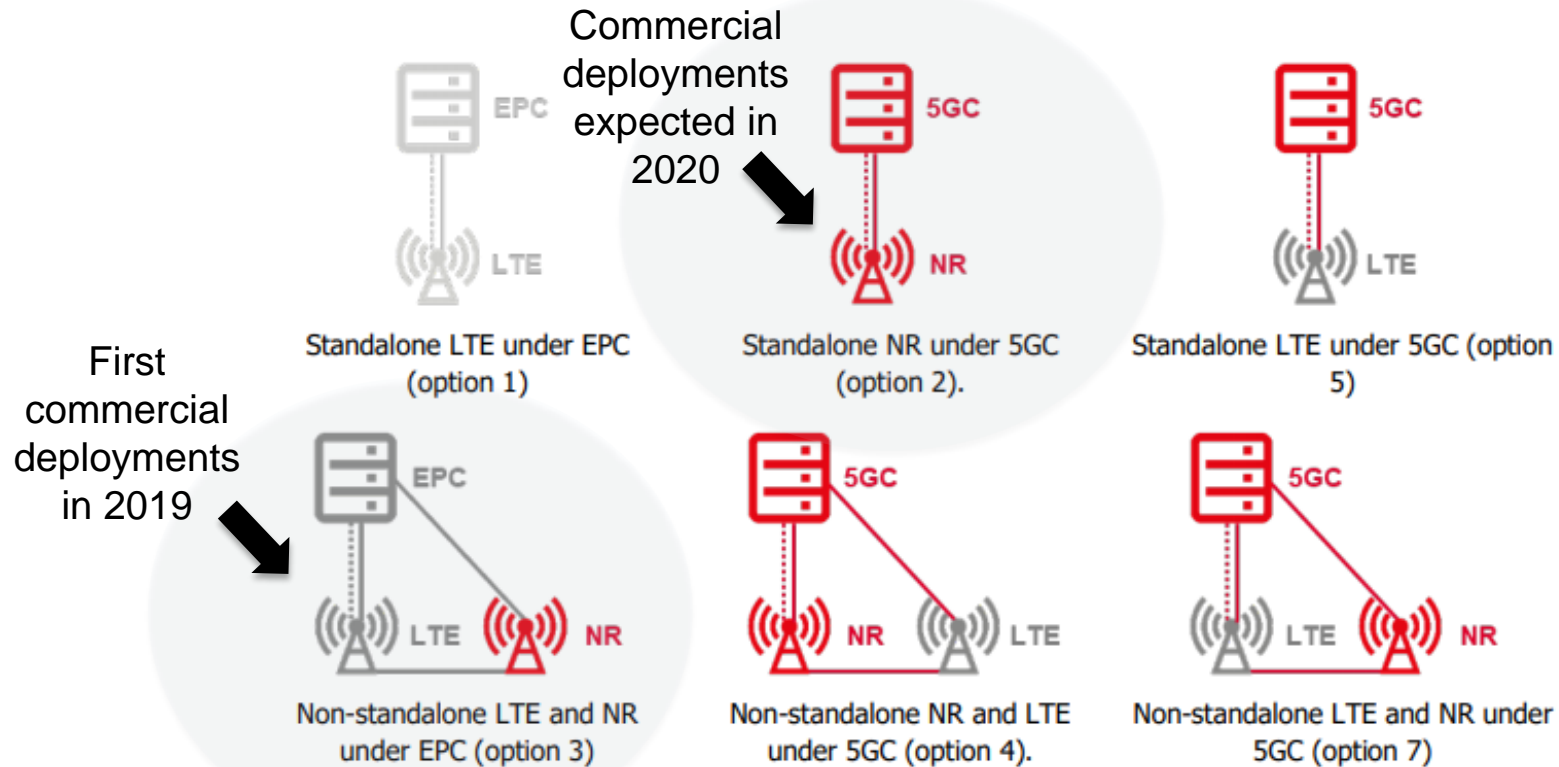
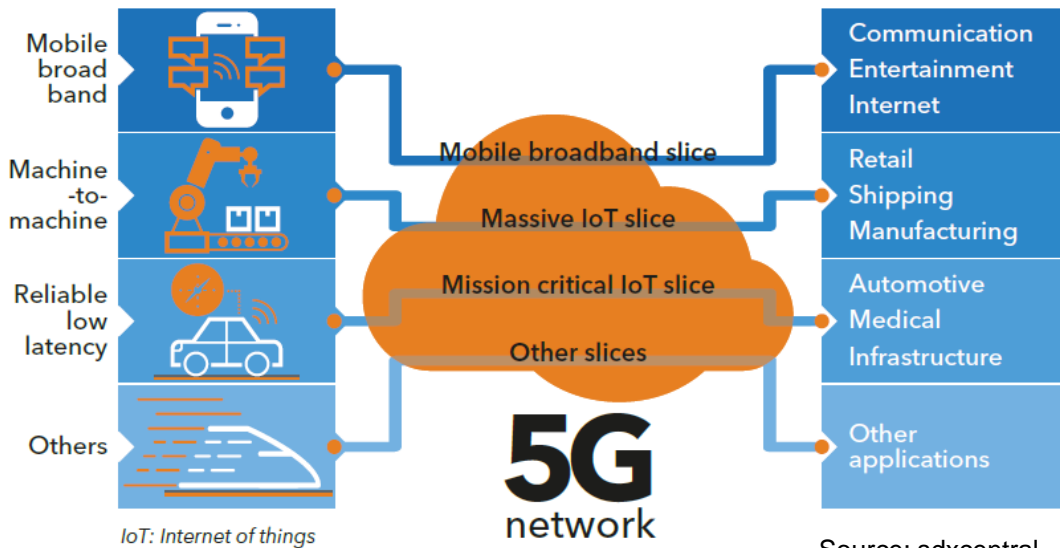# 5G WILL BE AN AGILE NETWORK THAT ADAPTS TO THE NEEDS OF DIFFERENT USE CASES

5G network slicing

5G network slicing enables service providers to build virtual end-to-end networks tailored to application requirements.

Mobile broad band — Mobile broadband slice — Communication Entertainment Internet

Machine-to-machine — Massive IoT slice — Retail Shipping Manufacturing

Reliable low latency — Mission critical IoT slice — Automotive Medical Infrastructure

Others — Other slices — Other applications

4G networks do not enable the range of services that the future requires. 5G will be faster and more flexible.

4G network

5G network

IoT: Internet of things

Source: sdxcentral

Key technology enablers

- Softwarization
- Network Function Virtualization
- Cloud Computing
- Edge Computing

TNO innovation for life

5G WILL ENABLE ENTERPRISES TO BUILD AND MANAGE THEIR OWN LOCAL NETWORKS ...

Unified local 5G network infrastructure to **flexibly** cater for a **wide variety of demands.**

e.g., TNO has shown how to build a "5G core network in 5 minutes"
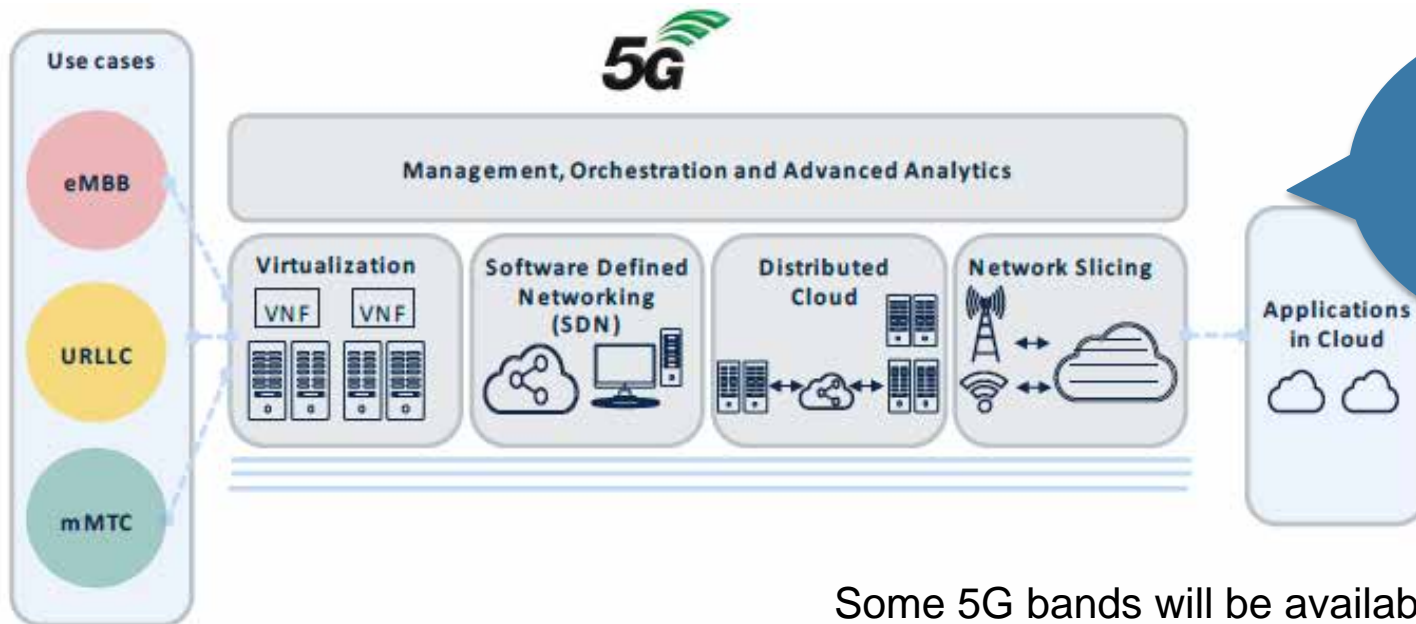
Some 5G bands will be available for local usage

TNO innovation for life

… AND LOCAL SLICES WILL NEED TO BE INTERCONNECTED WITH MOBILE OPERATOR SLICES

Local 5G network

Nationwide 5G network
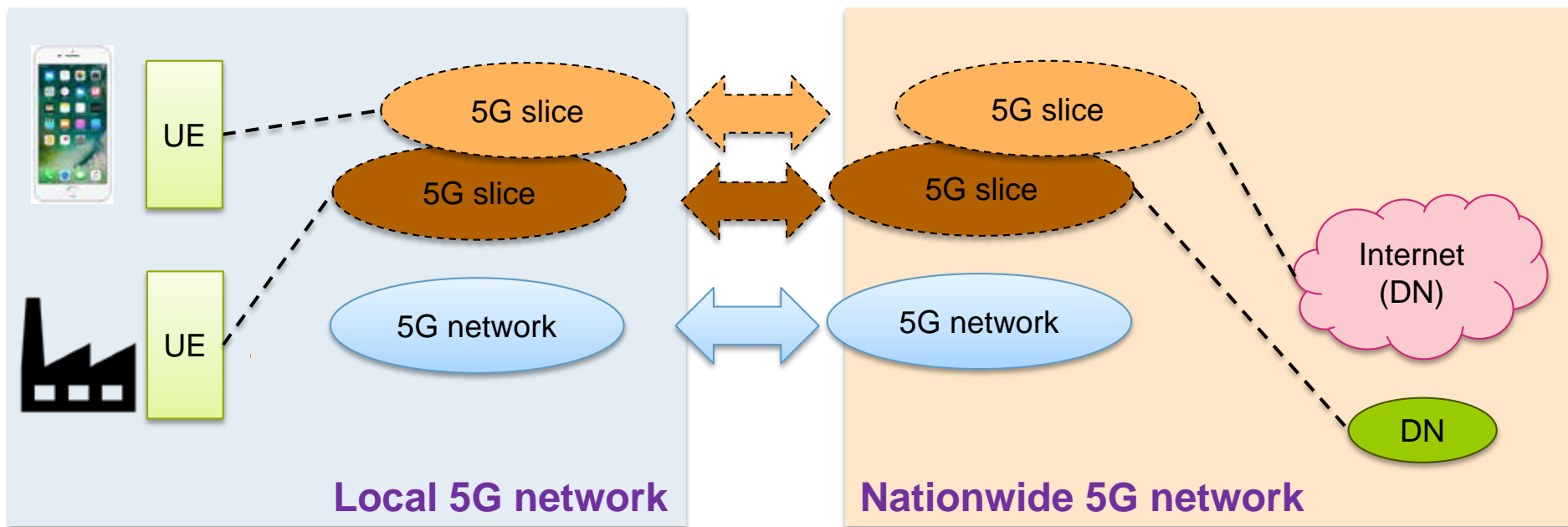
Only 5G slices **within** a 5G network are standardised right now.

TNO innovation for life

A FEW CHALLENGES FACED BY THE INDUSTRY

› **Cost:** heavy investments required by operators (e.g. as much as $275 billion before 2025 in the USA); business case/models still need to be established.

› **Spectrum**: commercial availability of 3,5 GHz spectrum in the Netherlands delayed to 2022.

› **Densification:** appropriate council regulations needed to enable densification, e.g. zoning policies, fees, aesthetic concerns, permitting processes, etc.

› **Interoperability and multi-operator slicing**: the most challenging 5G use cases (e.g. ultra reliable low latency communications) will require networks that are interoperable.

› **Perceptions surrounding the impact of 5G on health:** concerns around impact of millimetre waves, a lot of attention in the media and lobby groups.

5G TRIALS & USE CASES: FOCUS ON 5GRONINGEN

THE ENTREPRENEUR

THE REGION

5GRONINGEN
VERBONDEN MET DE TOEKOMST

THE FIELDLAB

THE STUDENT

THE FIELDLAB

20 PILOTS IN SECTORS RELEVANT IN THE RURAL AREA

	With:
• Healthcare	
• Agriculture	Drones
• Energy	Self driving cars
• Living environment	Virtual reality
• Traffic and logistics	360 camera's
• Smart Industry	Internet-of-things
• Education	Sensors

THANK YOU FOR YOUR ATTENTION

Adrian Pais
adrian.pais@tno.nl