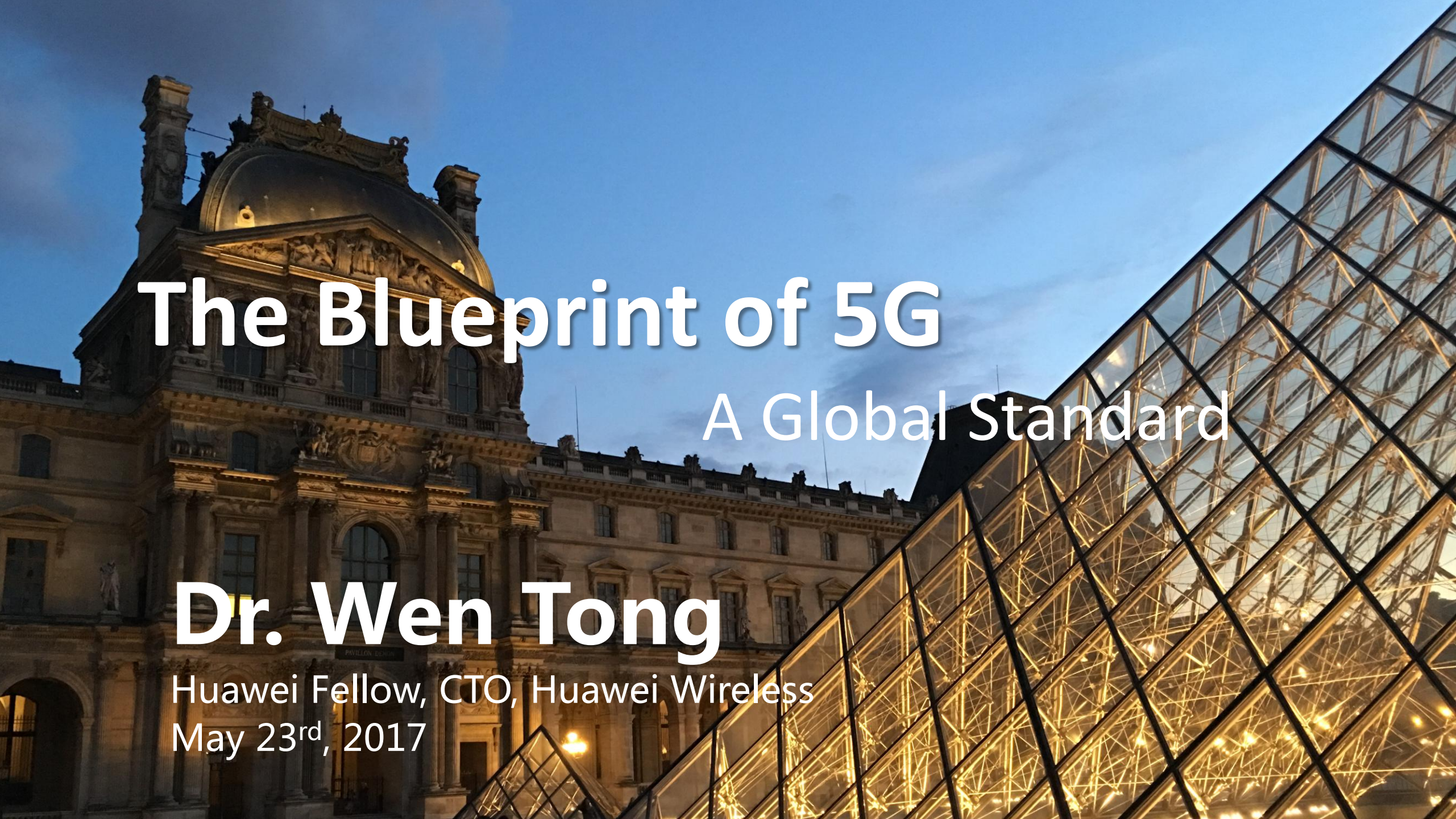


The Blueprint of 5G

A Global Standard

Dr. Wen Tong

Huawei Fellow, CTO, Huawei Wireless

May 23rd, 2017

5G: One Network Infrastructure Serving All Industry Sectors

- **5G unified air interface**

  Flexible to address diverse requirements

- **Network slicing**

  Providing customized and isolated slices to meet individual requirement on sharing infrastructure

- **5G design target**

  One network infrastructure to meet demands of all industry sectors to mobile and wireless communications

Accelerate to 5G Standardization Timetable

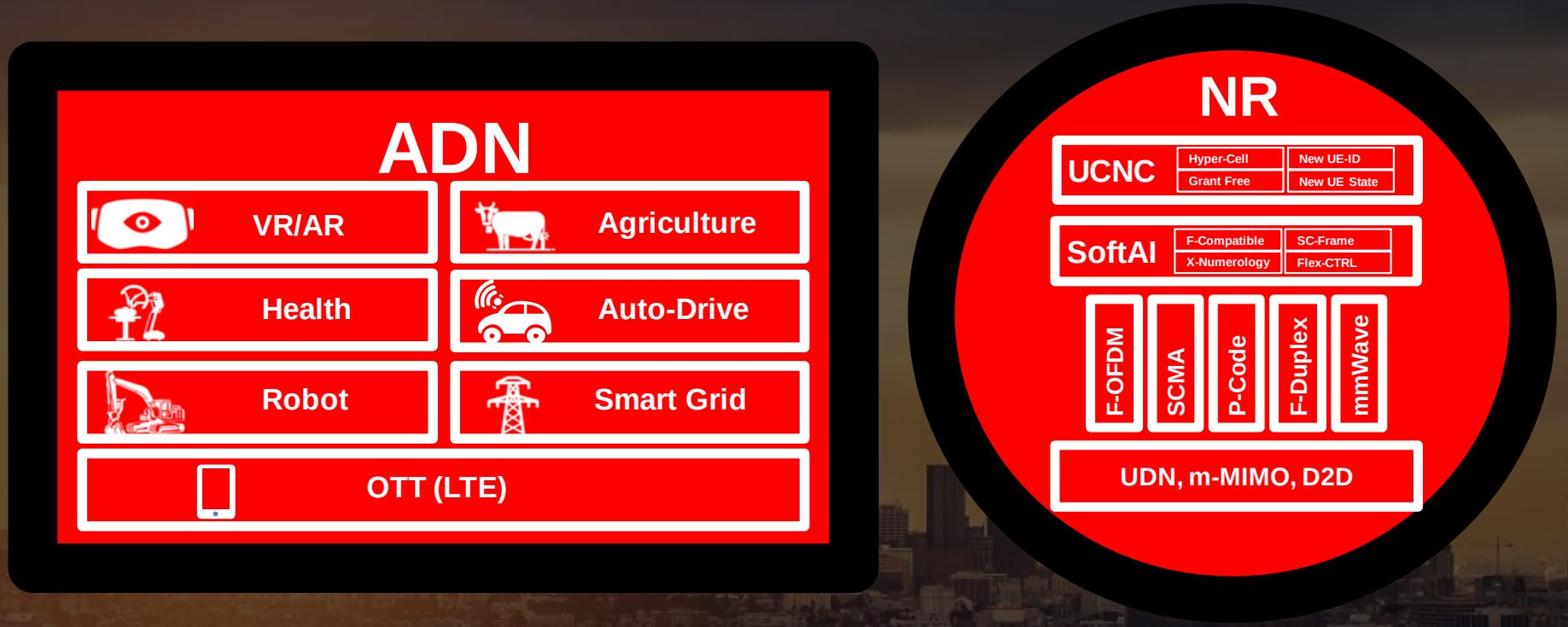
3GPP™ A GLOBAL INITIATIVE

RAN	Rel-13	Rel-14	Rel-15	Rel-16
Previous Plan			5G Phase 1	5G Phase 2
Accelerating Plan		Phase 1.1	Phase 1.2	Full IMT-2020 NR

Global Launch

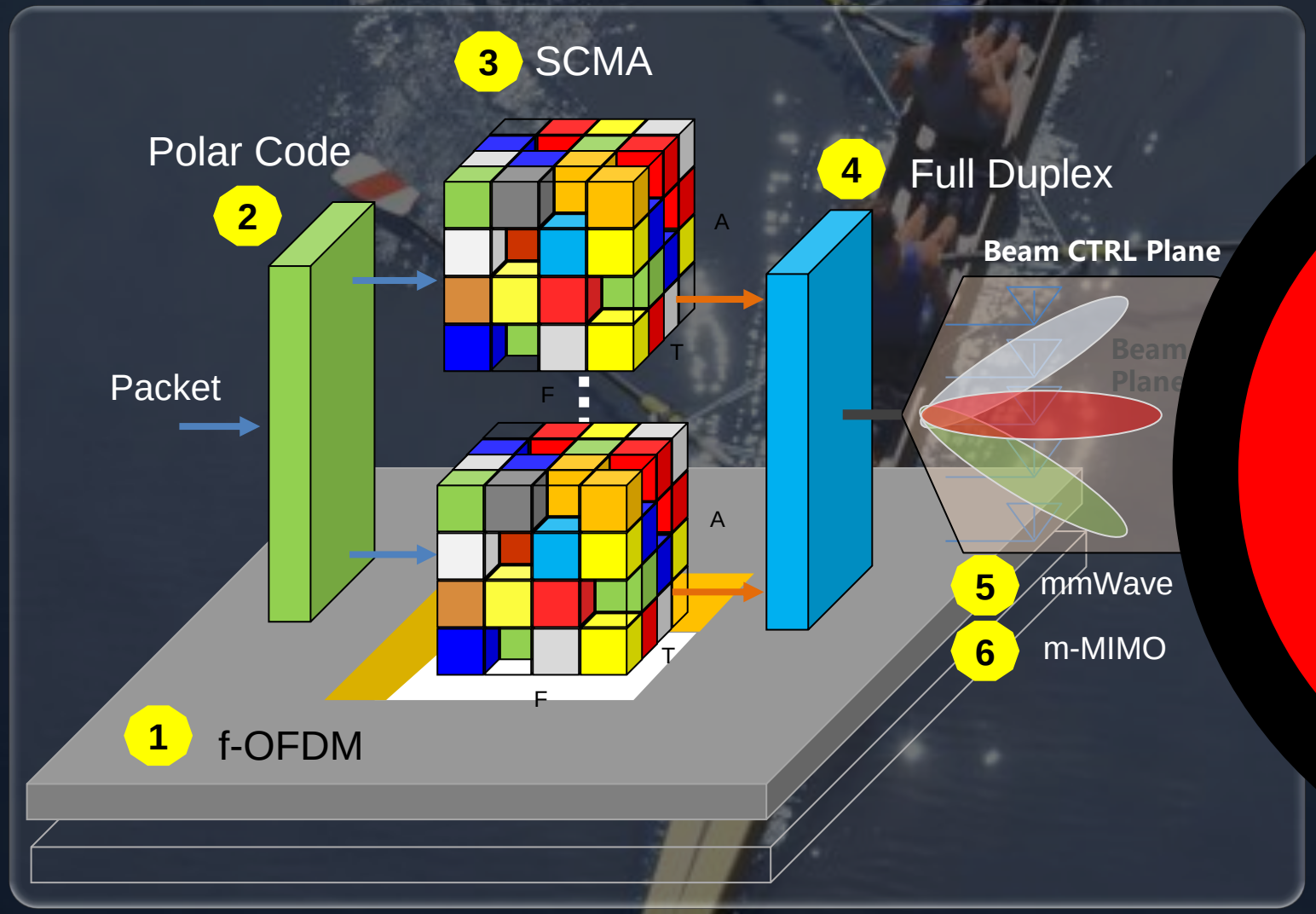
5G Unified Air Interface for Diverse Use Scenarios

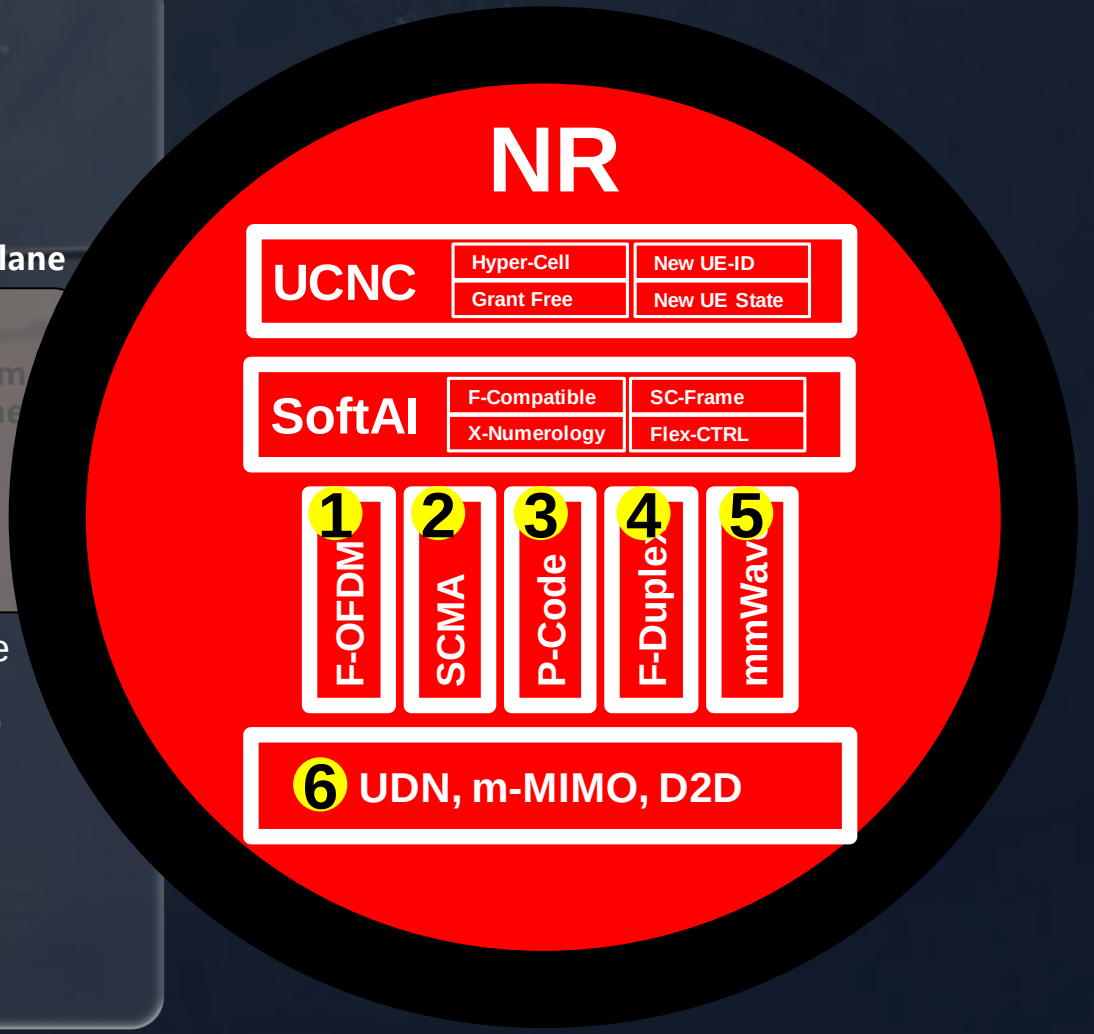
5G Networks Concept



5G Physical Infrastructure

5G-NR Air-Interface PHY Building Blocks

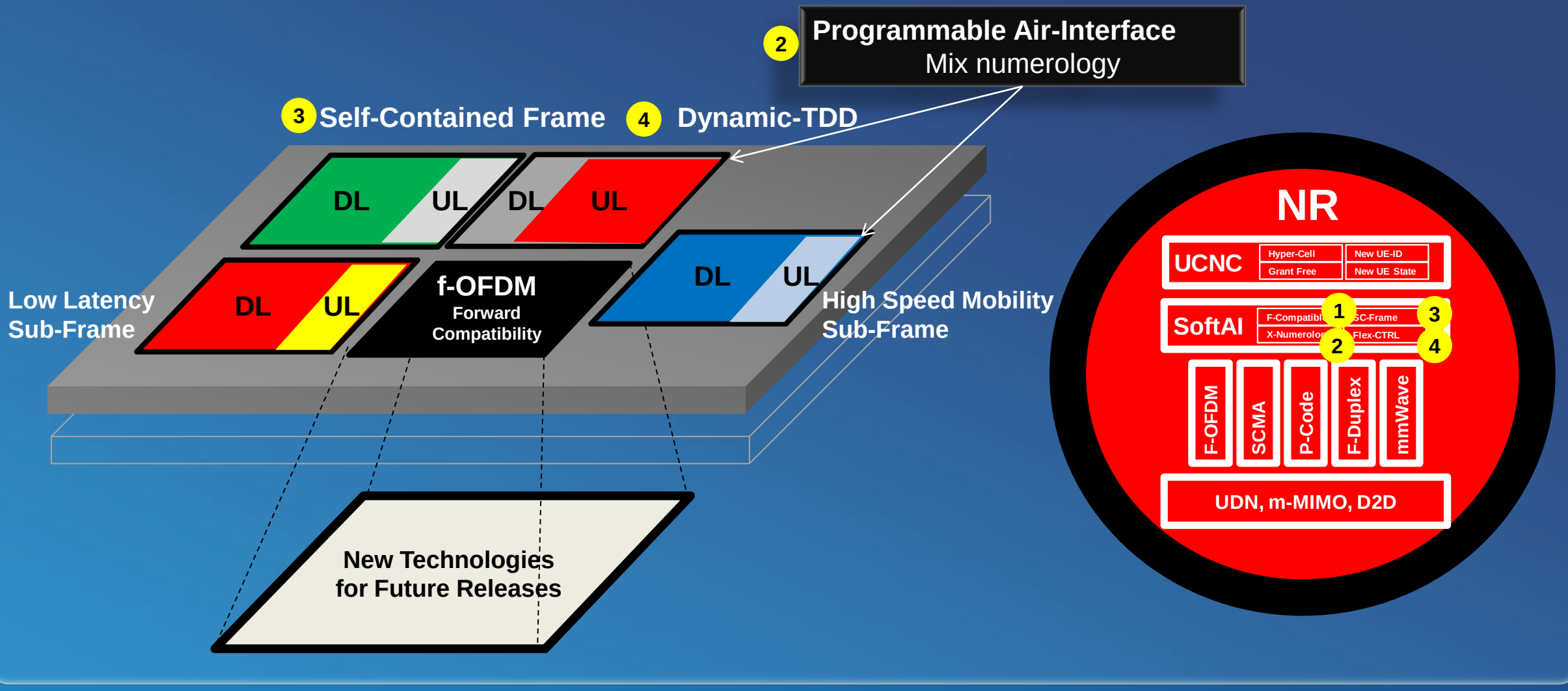




5G-NR Fundamentals – (1)

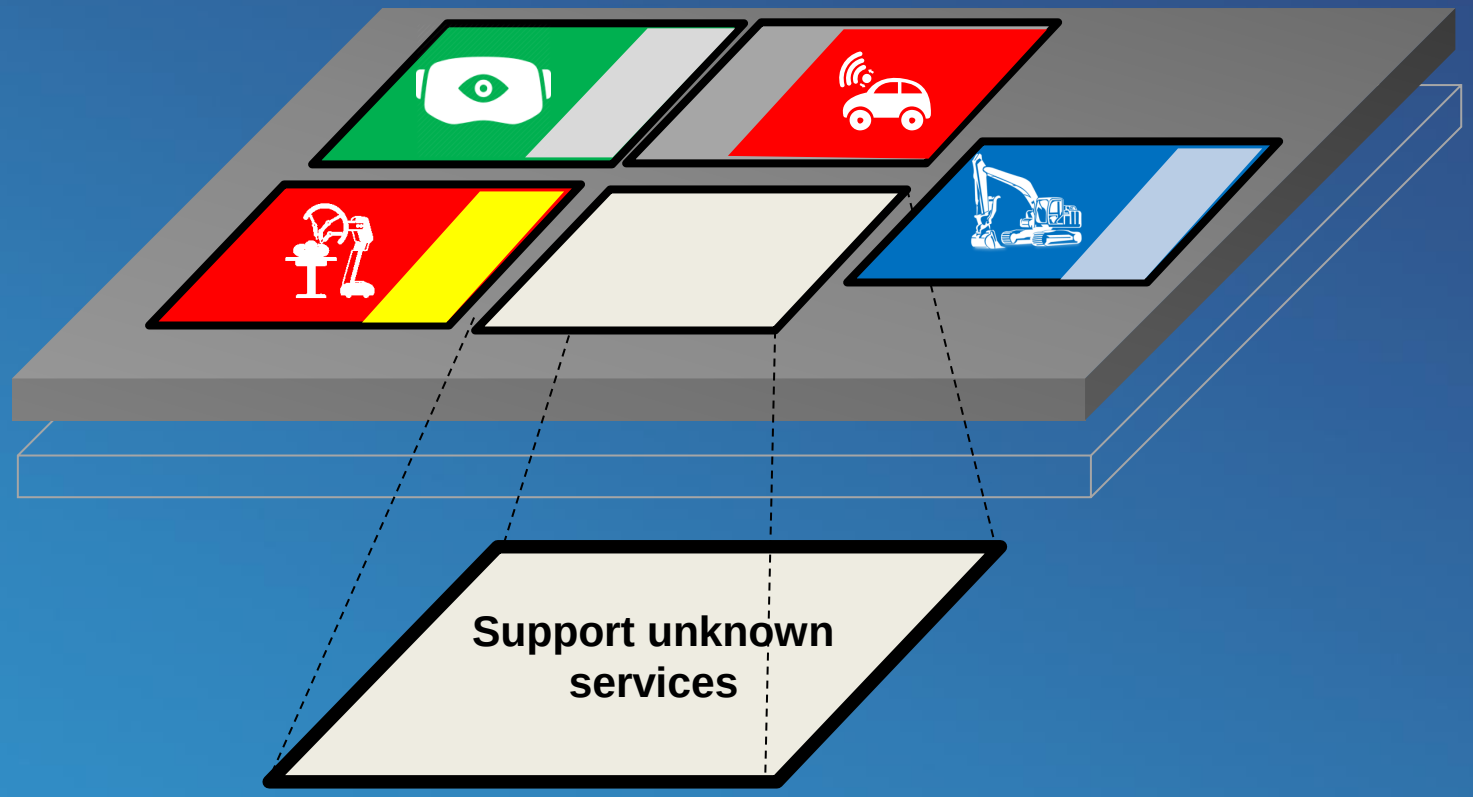
RAN Slicing

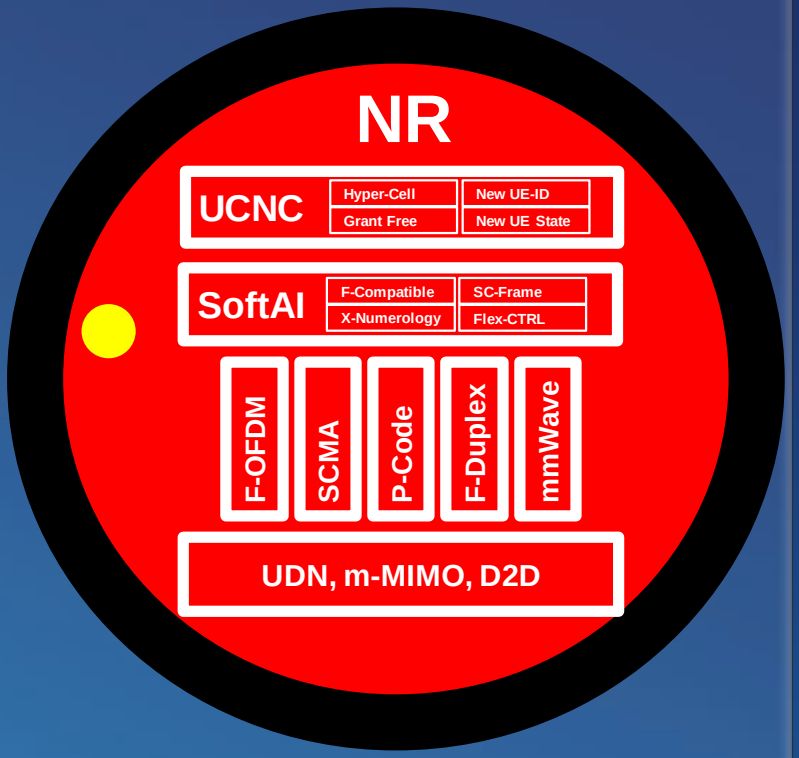
5G-NR Air-Interface Enables Radio Slicing



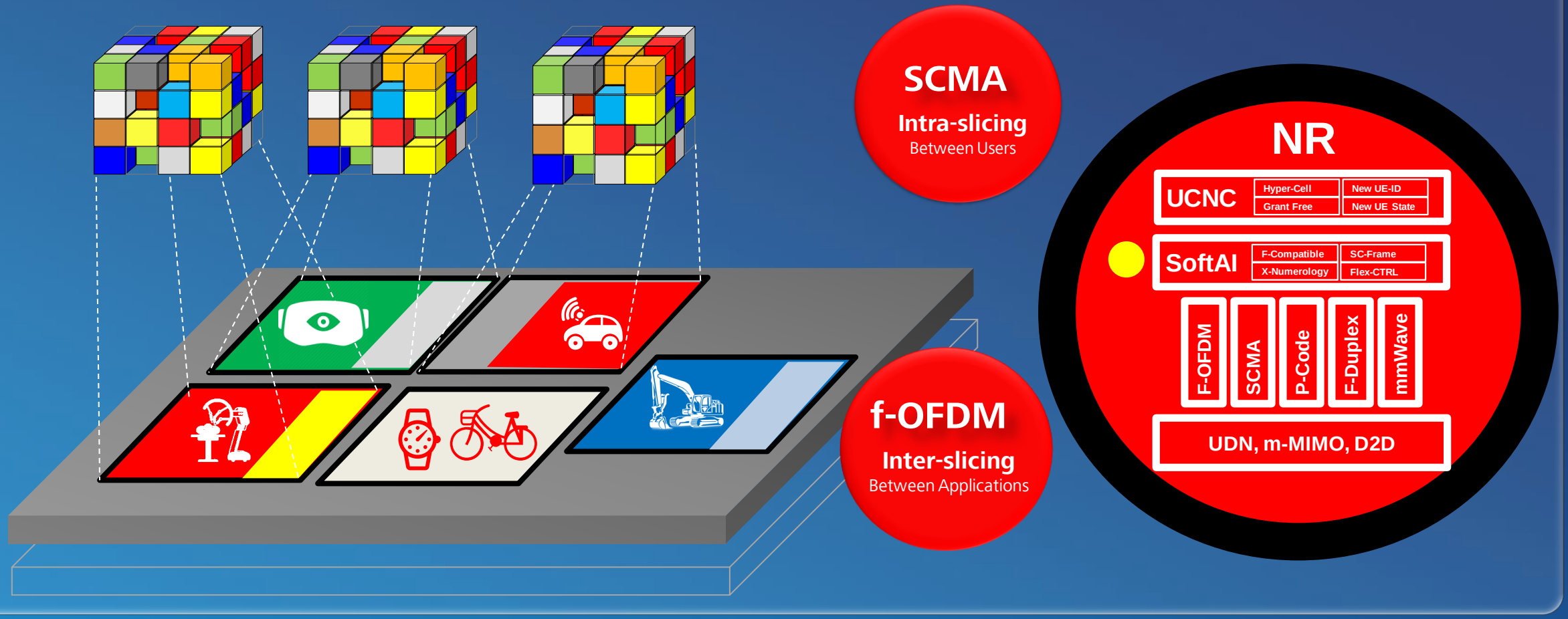
5G-NR Air-Interface Enables Radio Slicing

- Programmable Air-Interface for RAN Slicing

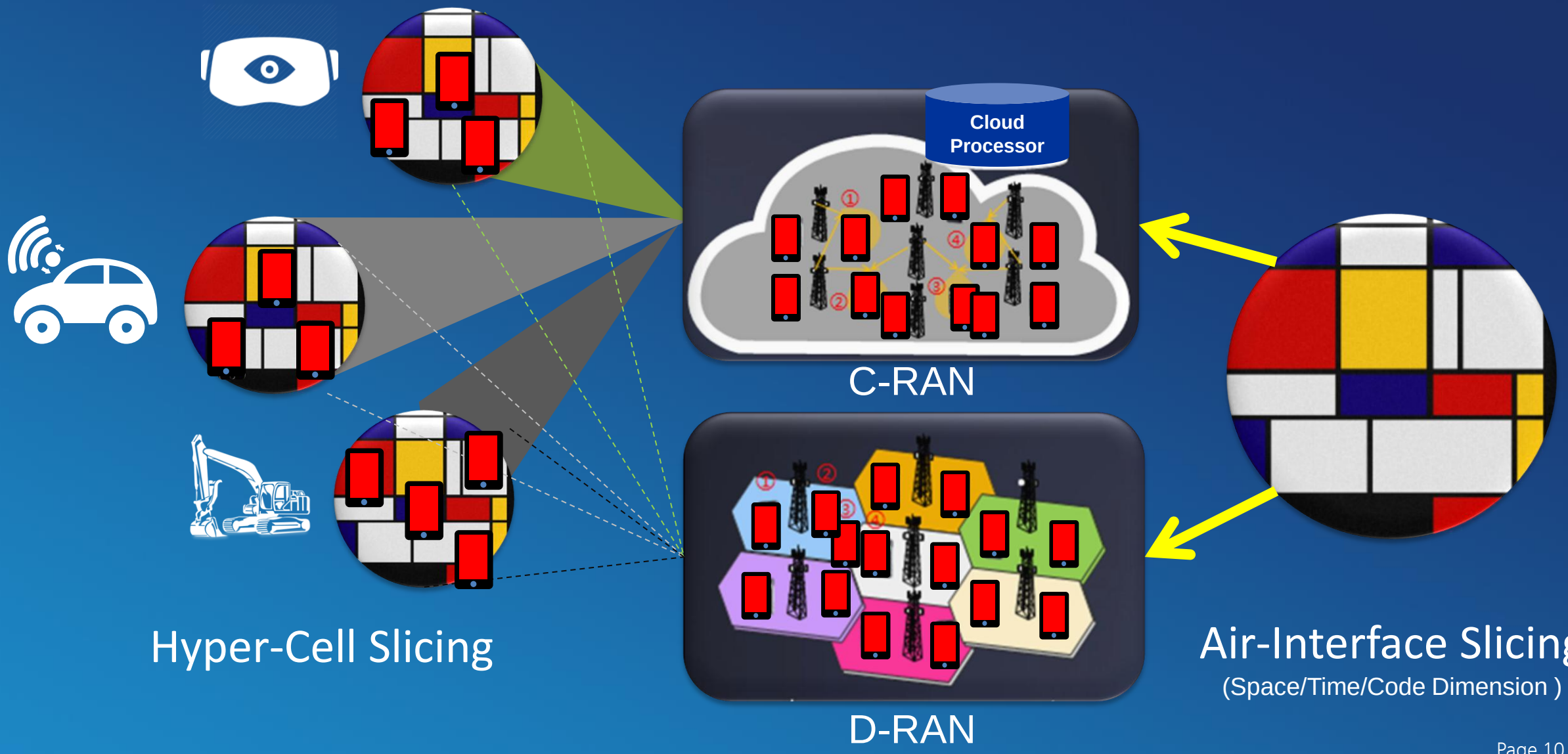




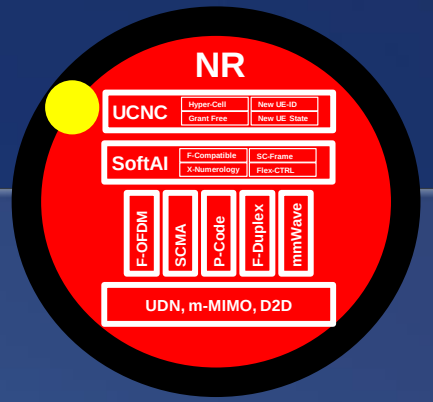
5G-NR Air-Interface Enables Radio Slicing



5G-NR Air-Interface Enables Radio Slicing

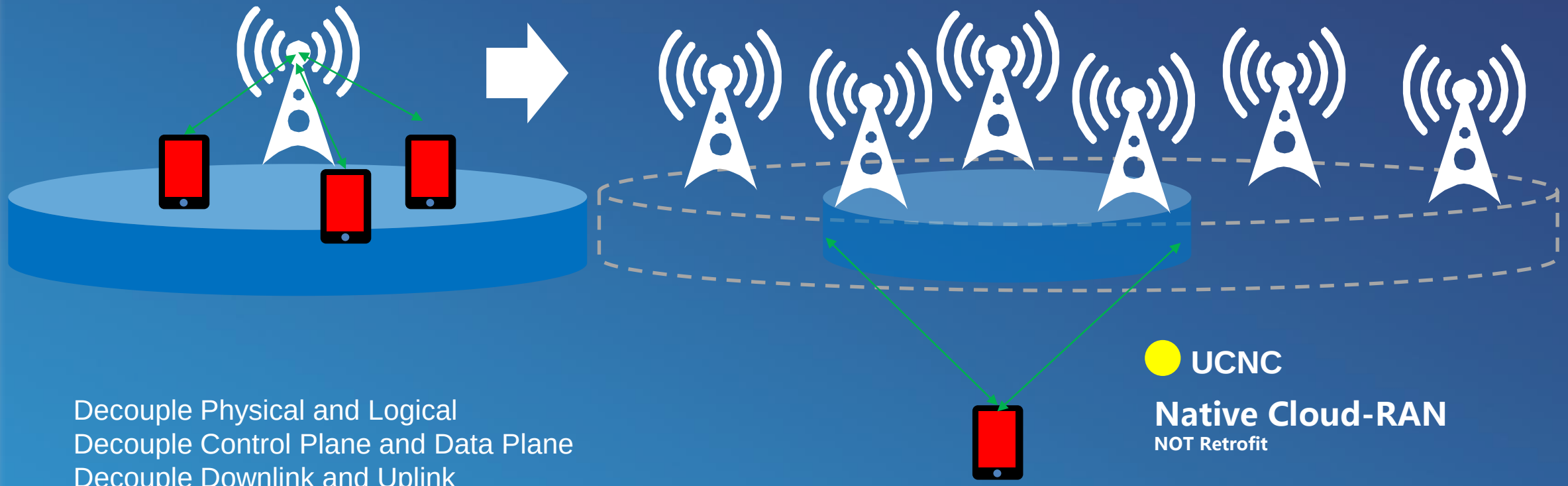


5G-NR Air-Interface - (No-Cell)



1G/2G/3G/4G

5G



Decouple Physical and Logical
Decouple Control Plane and Data Plane
Decouple Downlink and Uplink

UCNC

Native Cloud-RAN

NOT Retrofit

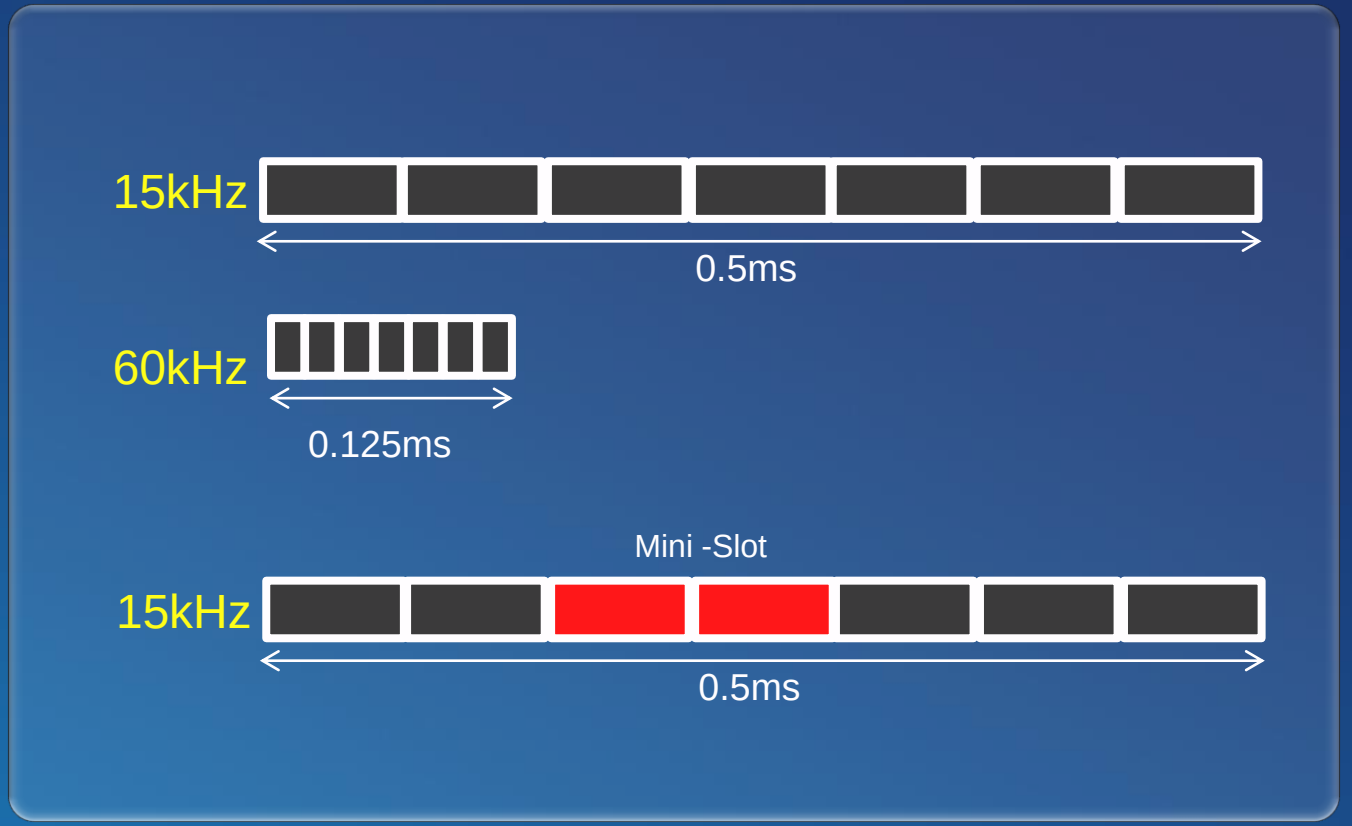
5G-NR Fundamentals – (2)

Low Latency

5G-NR Low Latency (Slot)

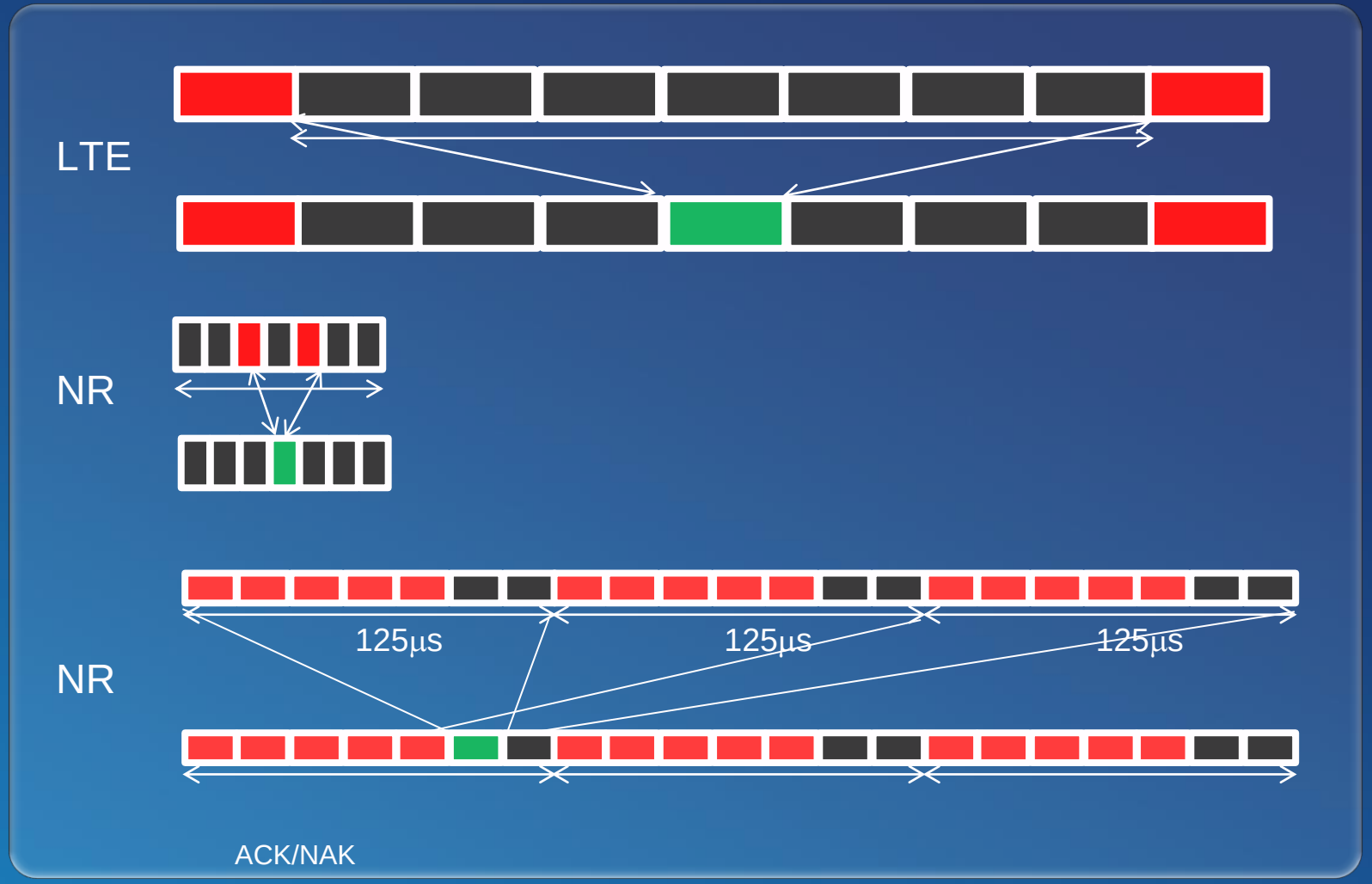
Short Scheduling Units

- Short Regular Slots
  - 0.5ms (15kHz numerology)
  - 0.125μs (60kHz numerology)
- Special Mini Slots
  - Arbitrary starting point and length with a slot
  - Enable lower latency for lower numerology



5G-NR Low Latency (HARQ Timing)

- Self-contained slot
  - DMRS/DCI localized
  - Rapid demodulation
- Shorter Slots and Fewer HARQ Interlaces
  - 30X latency Reduction
- 2 Interlace Re-transmissions
  - 250μs for 60kHz numerology



5G-NR Low Latency (Mini-Slot)

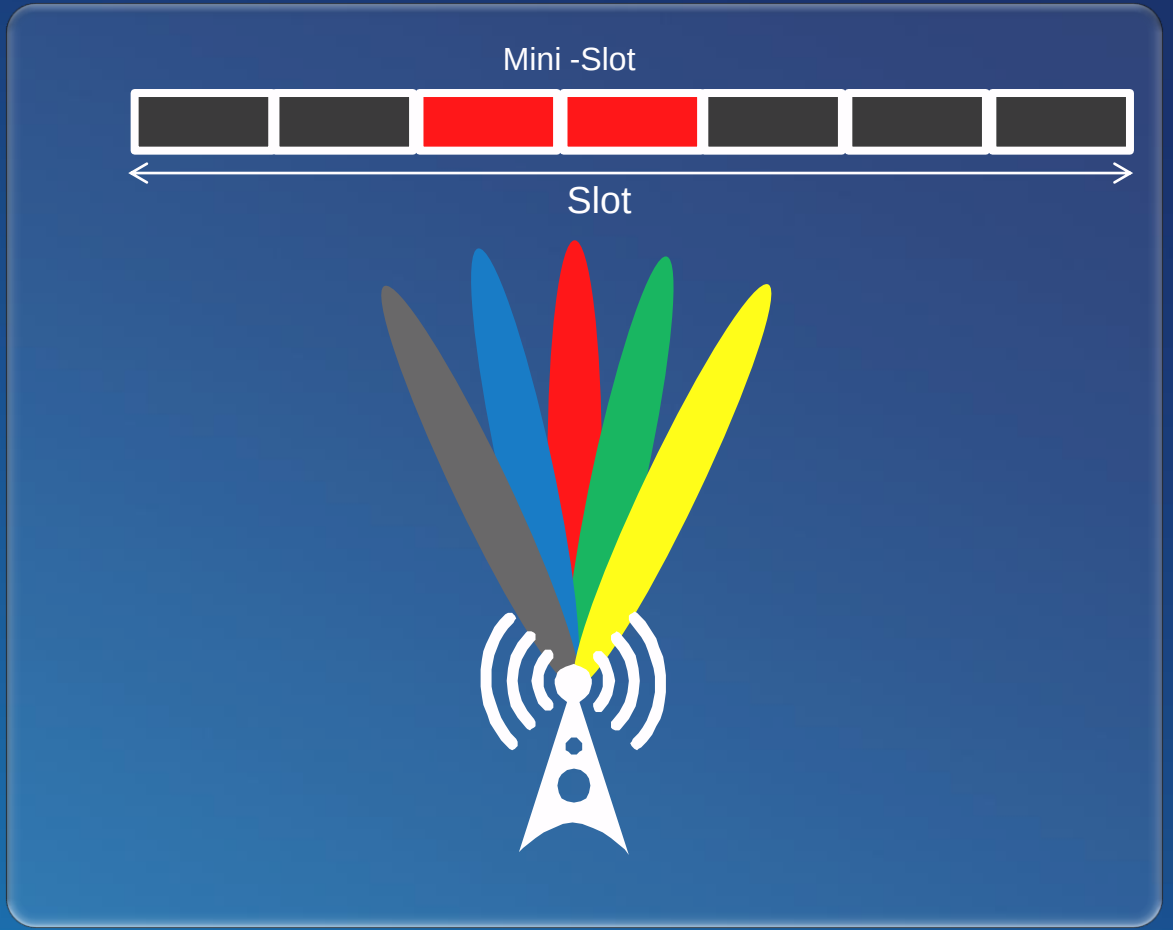
Mini-Slot Scheduling Granularity

- Suitable for mmWave
  - Large Bandwidth
  - Analog Beamforming (TDM scheduling)

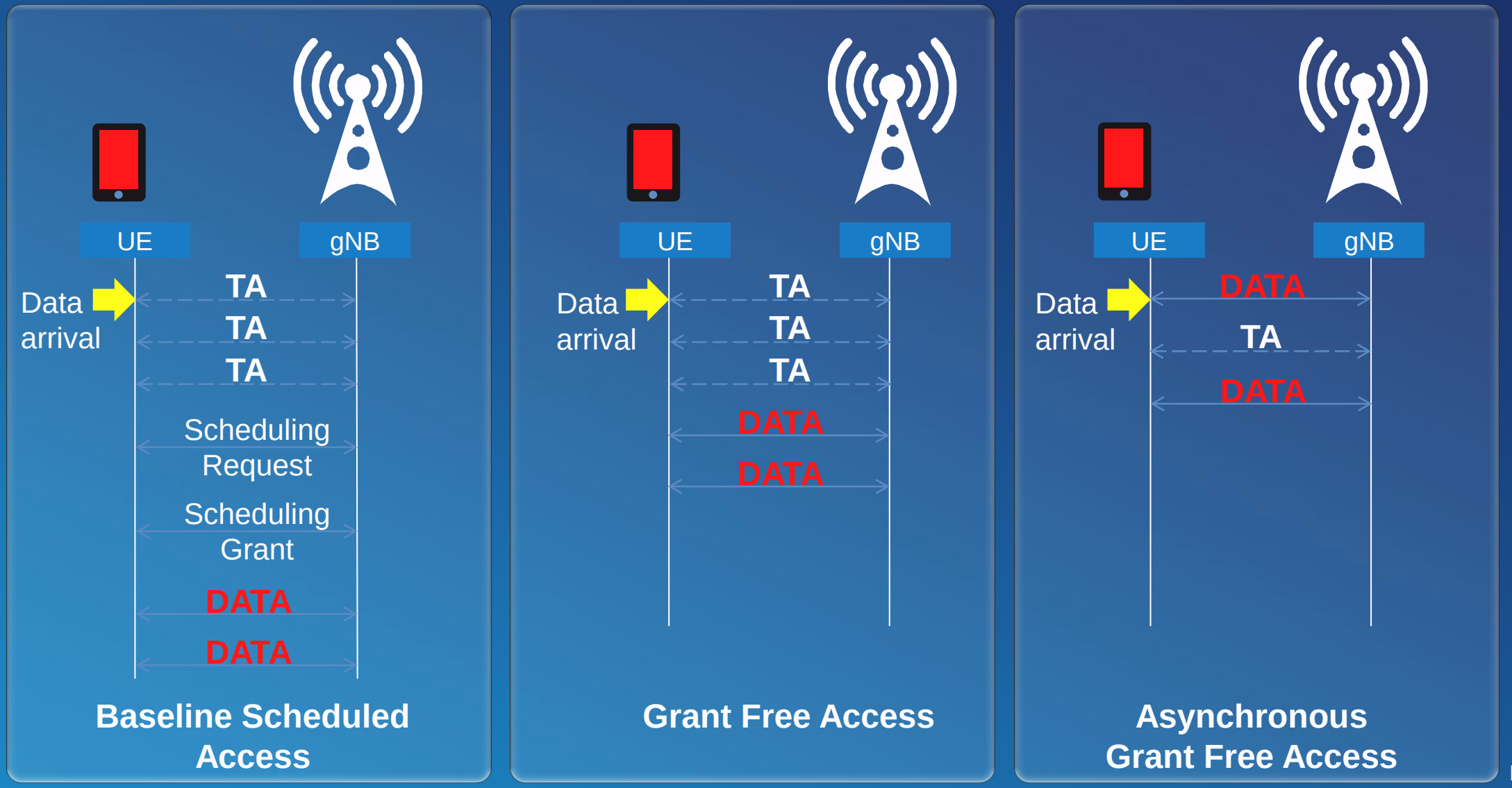
Slot based Scheduling Granularity

Suitable for sub-6GHz

- mmWave can result in large schedule unit
- Finer scheduling granularity

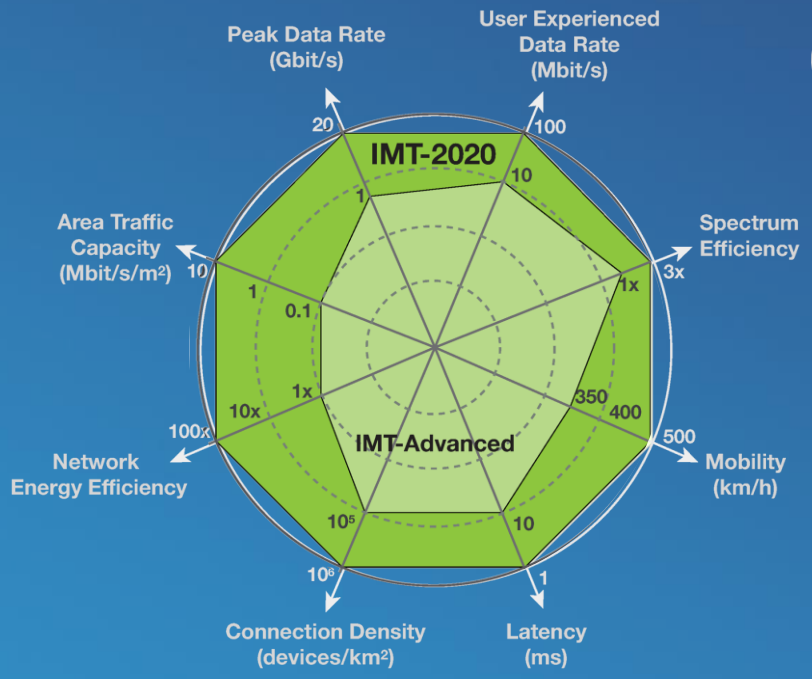


5G-NR Low Latency (Grant-Free)



UCNC to Meet Demands of 5G Capabilities (Trial Results)

User Centric No Cell RAN for NR



Reduce Signaling Overhead	81.2%
Reduce Transmission Latency	94.9%
Improve Connectivity Density	200%+
Improve Edge Spectrum Efficiency	200%

5G-NR Forward Compatibility Principle

(Lesson Learnt)

LTE Limitations (e.g.)

- **NR Signals Localization in Time and Frequency** → PDCCH, PCFICH, PHICH
  - Minimize spread in time and frequency
    - Date Plane: HARQ and fast demodulation
- **Remove high duty cycle signals** → Always-on CRS, high-duty-cycle sync signals, broadcast system information, …
  - Avoid design Always-on-Transmission
    - Control Plane: broadcast, synchronization, CRS
- **Avoid strict bounding with slot, frame and duplexing** → Uplink HARQ
  - Can be re-defined in the future

5G-NR Fundamentals – (3)

Spectral Efficiency

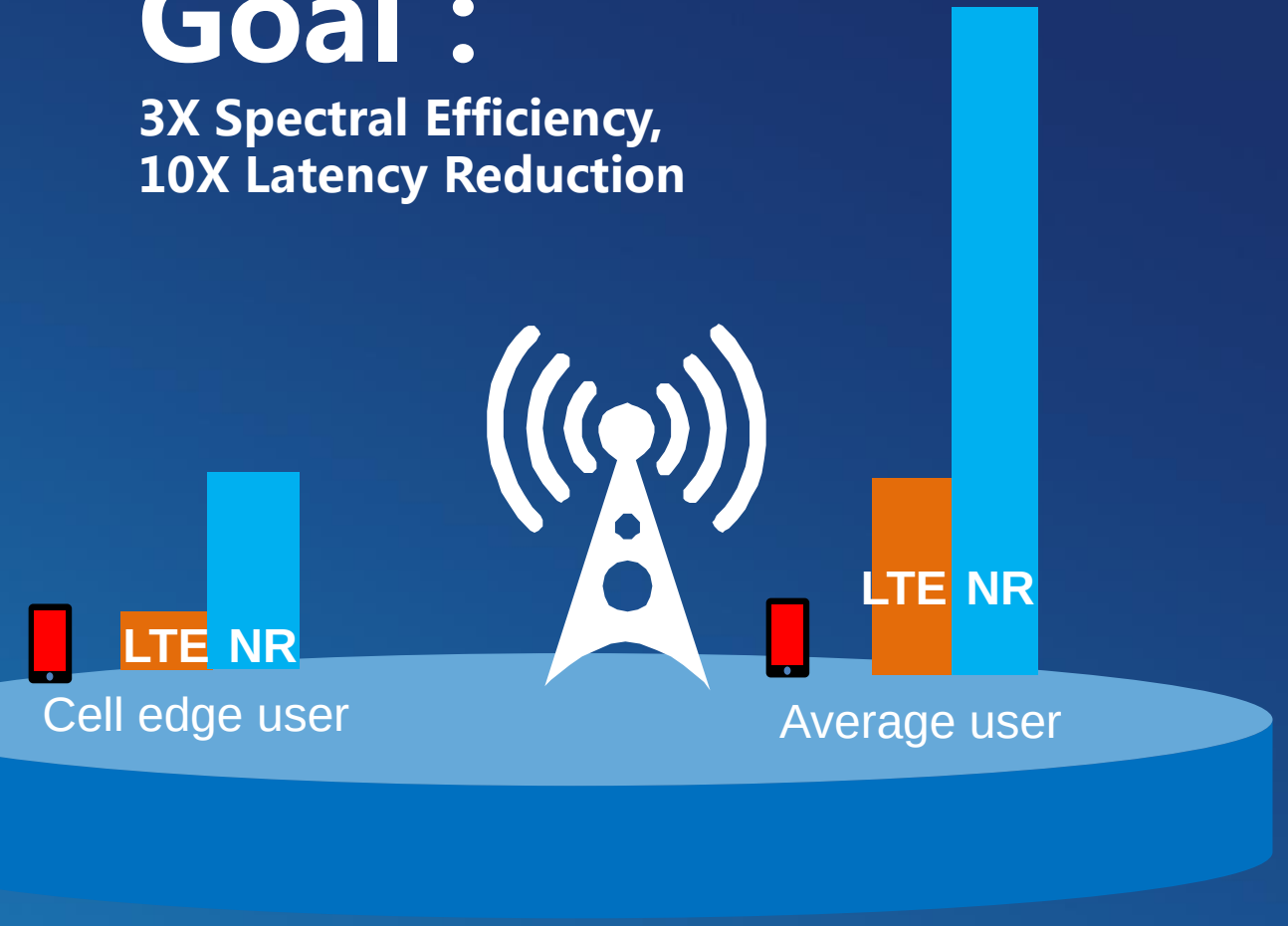
5G-NR Cellular Bands Spectral Efficiency

sub-3GHz 2x2 FDD: Baseline: R-12 LTE-A (eMBB)

		5G-NR	
Spectral Efficiency Gain Factor		**DL**	**UL**
Non-Orthogonal Access	SCMA	★1.4	2.3
Mixed Numerology	f-OFDM	1.08 [Note:1]	1.08 [Note:1]
Non-Linear MIMO Pre-Coding	Dirty Paper Coding	1.10 [Note:2]	1.0
Channel Estimation, HARQ Optimization	0.1ms TTI (Self-Contained)	1.15 [Note:3]	1.0
DL Signaling Reduction	Grant-Free	1.20 [Note:4]	1.3 [Note:5]
SIC Receiver	UCNC	★1.30 [Note:6]	1.0
Spectral Efficiency Gain		**3.01**	**3.3**

Goal :

3X Spectral Efficiency,
10X Latency Reduction



[Note:1] Filtered-OFDM remove guard bands
[Note:2] TH pre-coding, SVD at eNB, constellation re-mapping at UE
[Note:3] Short-TTI optimization link adaption, channel estimation improvement , optimization of HARG
[Note:4] Remove UL Grant signaling, UL40% big packet， 60% 30Bytes (For UL100% small packet, Grant signaling takes 35% DL capacity)
[Note:5] Remove UL Grant signaling, Re-Entry and system Entry signaling
[Note:6] BBU C-RAN based data plane, requires UE with SIC receiver (or re-use SCMA receiver)

★ Require advanced receiver at UE

5G-NR Co-exists Launch-pad (NR+LTE)

NR+LTE on the same carrier

NR Utilization of LTE “Holes”
LTE Utilization of NR “Holes”

NR+LTE Dual Connectivity (Standalone)

LTE+NR

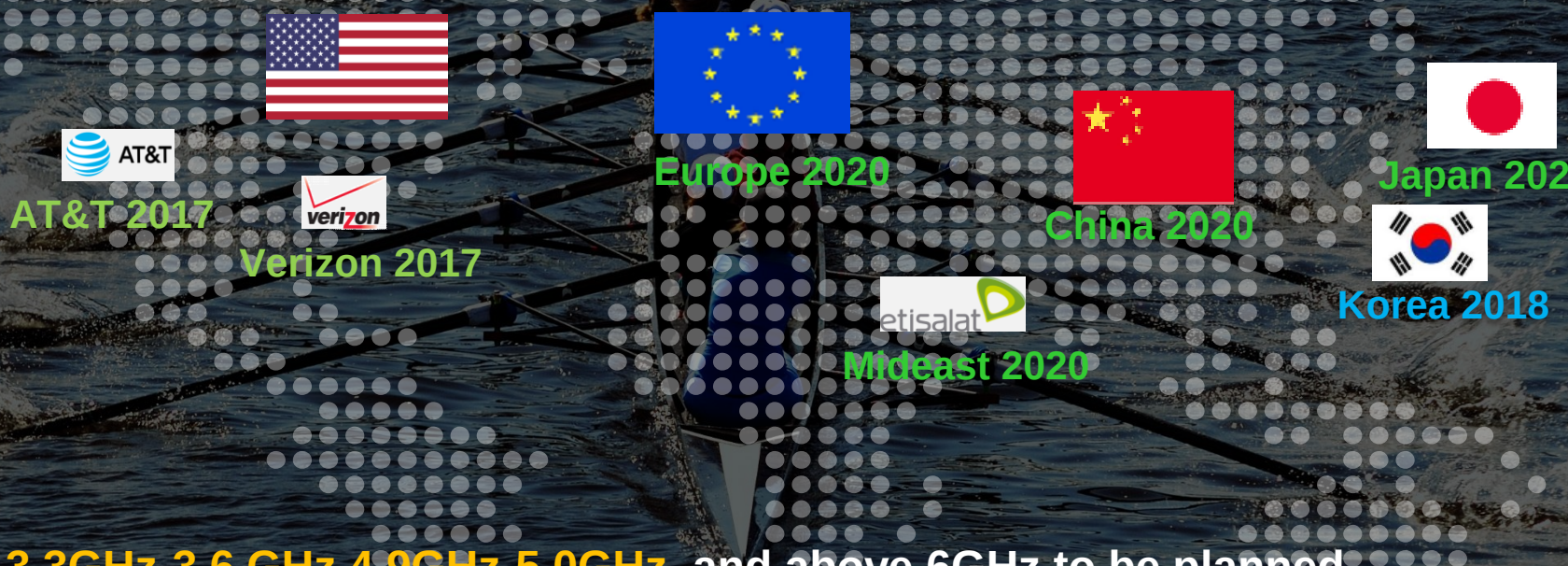
Partial NR Signals in LTE Uplink Supplementary NR Uplink Concept

NR+LTE Dual Connectivity (Non-Standalone)

LTE

NR

Priority to C-band and Coordination with High Bands



- China：3.3GHz-3.6 GHz 4.9GHz-5.0GHz, and above 6GHz to be planned
- Europe：3.4GHz-3.8 GHz recommended by for 5G，700MHz for IMT（4G/4.5G/5G）before 2020, High Frequency（25GHz, 32GHz, 42GHz）to be confirmed
- Korea：26.5GHz-29.5 GHz, 3.4GHz-3.8GHz for 5G trial
- Japan：3.4GHz-4.2GHz, 4.4-4.9 and high frequency under evaluation for 5G availability
- USA：FCC announced 27.5-28.35 and 37-40GHz for 5G

First Concrete Step of Cross Industry Collaboration

5GAA Automotive Association

5G Automotive Association (5GAA)
Founded in Munich, September 27, 2016

Audi · BMW · DAIMLER · ERICSSON · HUAWEI · intel · NOKIA · QUALCOMM · vodafone

- Usage Scenario
- Standardization & Regulation
- Technical Research
- Interoperation Test


merci beaucoup !