



**KEYSIGHT**  
**WORLD 2019**

# Realizing the Vision of 5G

*Kailash Narayanan*

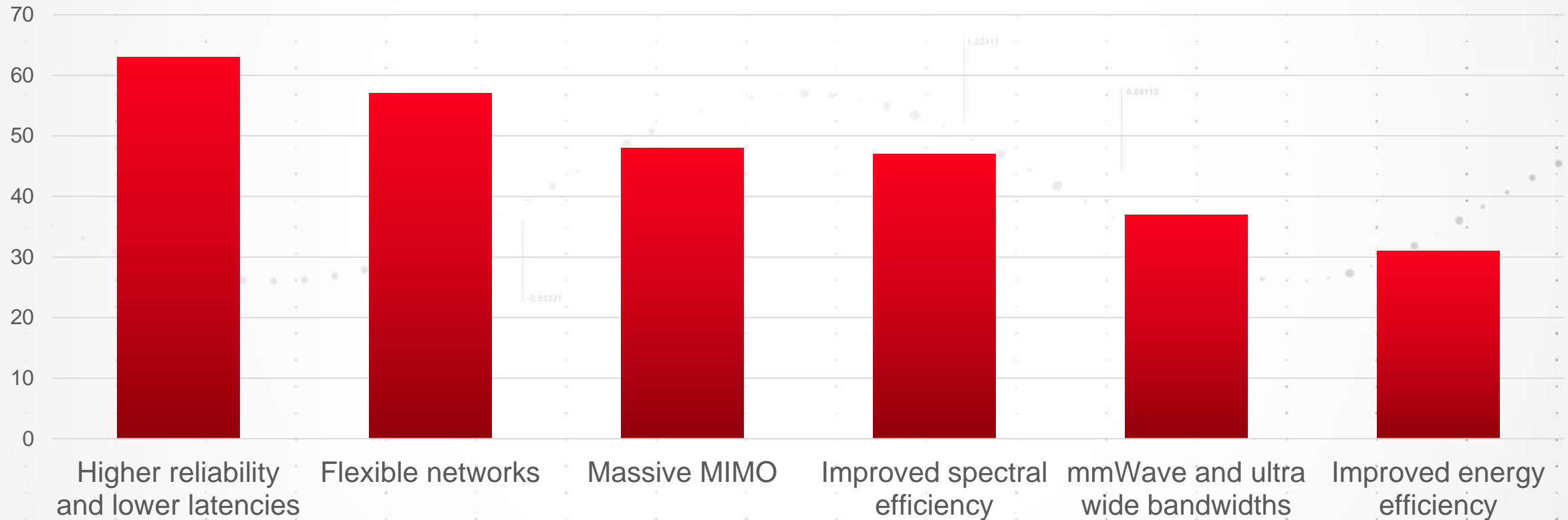
*Vice President, Wireless Test Group, Keysight Technologies*



# Market Leadership Key Driver for 5G Investments

TO ACHIEVE HIGHER RELIABILITY, LOWER LATENCIES AND FASTER NETWORKS

Which 5G technologies will deliver the most significant impact?





# 5G Will Change The World

**\$3.5**  
trillion

5G mobile value chain by 2035

**25%**  
of all  
traffic

carried by 5G networks by 2024

**4.1**  
billion

cellular IOT connections by 2024

**22**  
million

jobs supported by 5G by 2035

**40%**  
global  
population

covered by 5G



# **5G – State of the Industry**

## **Deployments Are Accelerating**



# 5G Charges Ahead

**Mobile operator deployments** are accelerating

**Network architecture** is transforming


















**5G NR standards** are evolving

**First wave of devices** available for trials



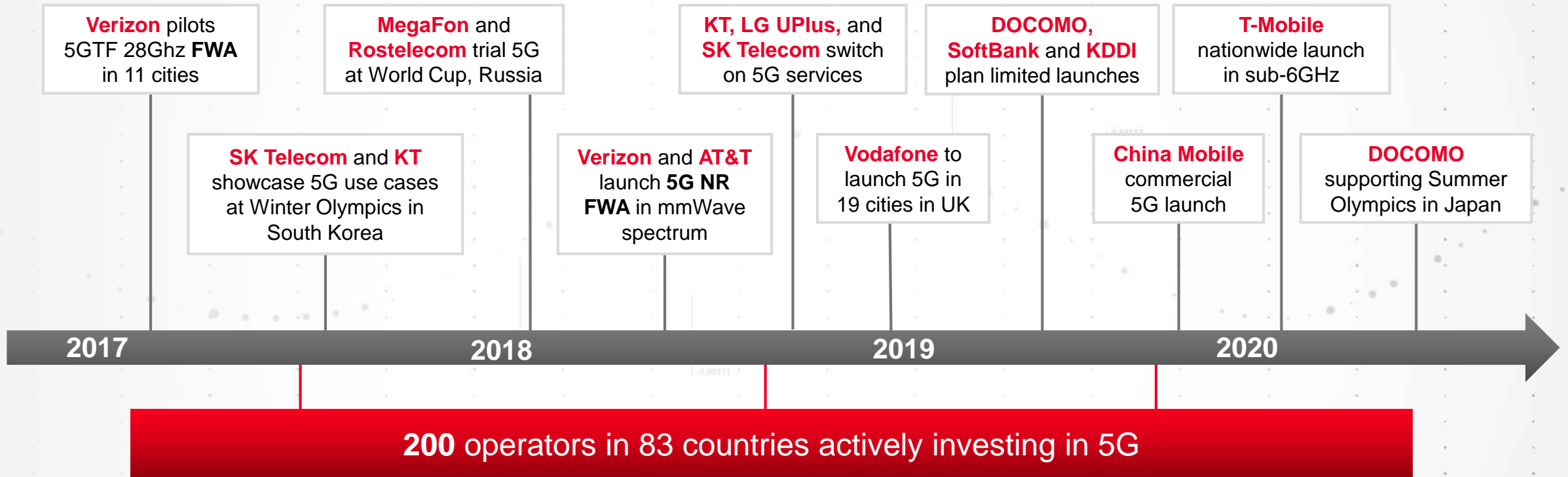
# 5G Deployment Map

5G BECOMING GLOBAL AND MAINSTREAM

|                     | FR1 (Sub-6GHz)  |   |   |   |   | FR2 (mmWave)  |   |   |   |
|---------------------|---|---|---|---|---|---|---|---|---|
| Spectrum            | <1GHz   | 2.5GHz  | 3.4 – 3.7GHz  |   | 4.4 – 4.9GHz  | ISM   | 28GHz   | 39GHz   |   |
| GEOGRAPHY           |  |  |   |  |  |  |  |  |  |
| OPERATOR            |  |  |  |  |  |   |  |  |  |
| COMMERCIAL SERVICES | Launch T-Mobile 2019<br><br>AT&T 2020   | Launch Sprint Early 2019<br><br>CMCC 2020   | Launch Vodafone Orange EE Three TIM 2019/2020                                       | Launch CTC 2020<br><br>KT & SKT 2019  | Launch Docomo 2020<br><br>Docomo / Softbank 2020                                    |   | Launch VZW 2018<br><br>AT&T, T-Mobile 2019  | Launch Docomo / Softbank 2020<br><br>KT & SKT 2020                                  | Launch AT&T 2018<br><br>Verizon, T-Mobile 2019                                      |

# Global 5G Deployments

## KEY MILESTONES





# **5G is About Network Transformation**

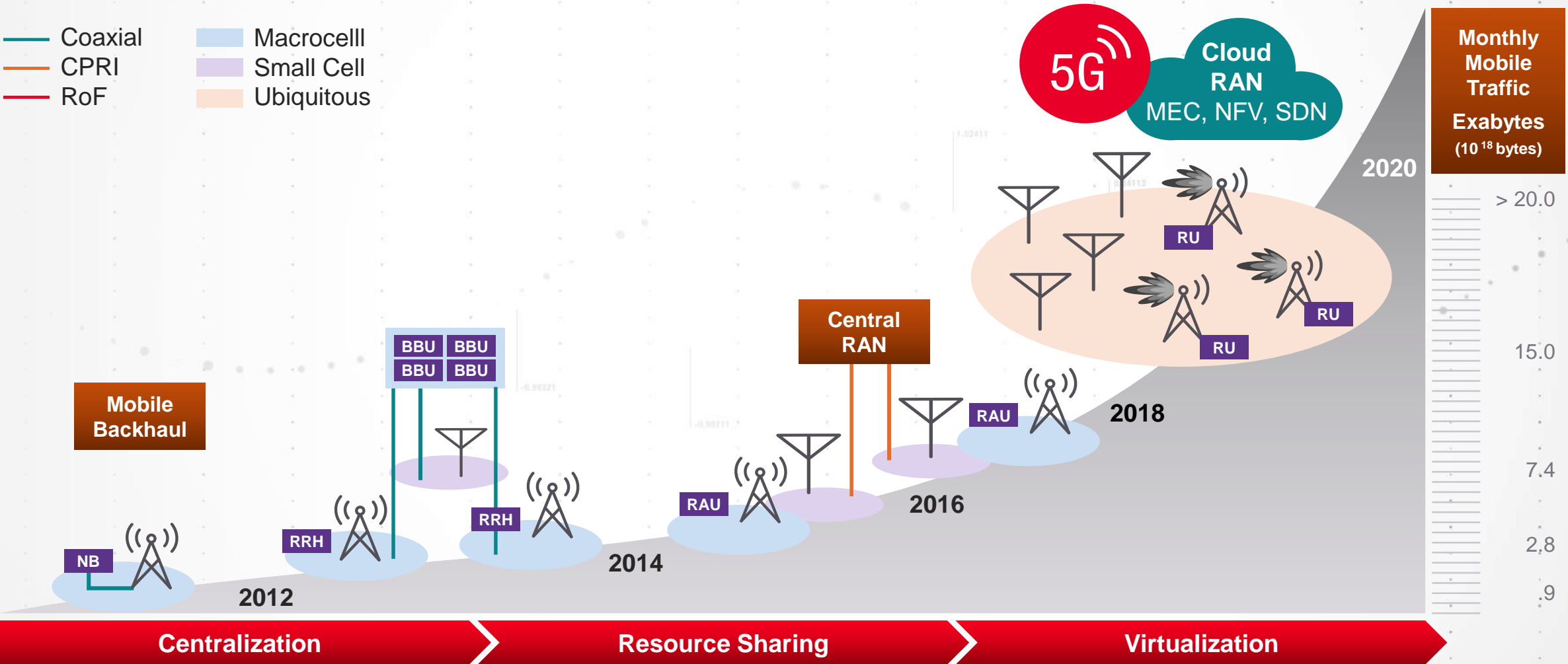
## **Vertical Industry Demands and Challenges**





# New Network Architecture

## ENABLING NEW BUSINESS MODELS



# Heterogenous Networks

## INCREASING DEPLOYMENT COMPLEXITY



### Core Network

- Multi-RAT Management
- Routing/Scheduling to address each vertical
- Interference management



### Small Cell



### Macro

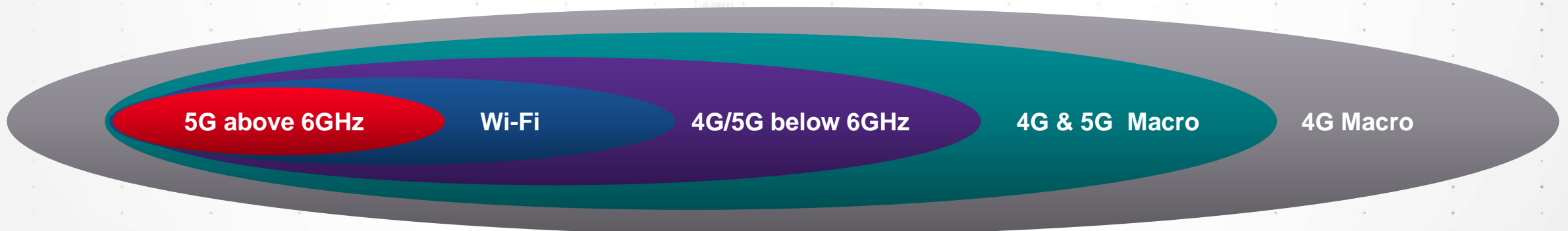
More complex:

- Site acquisition
- Network planning
- Resource management



### Multi-Mode Devices

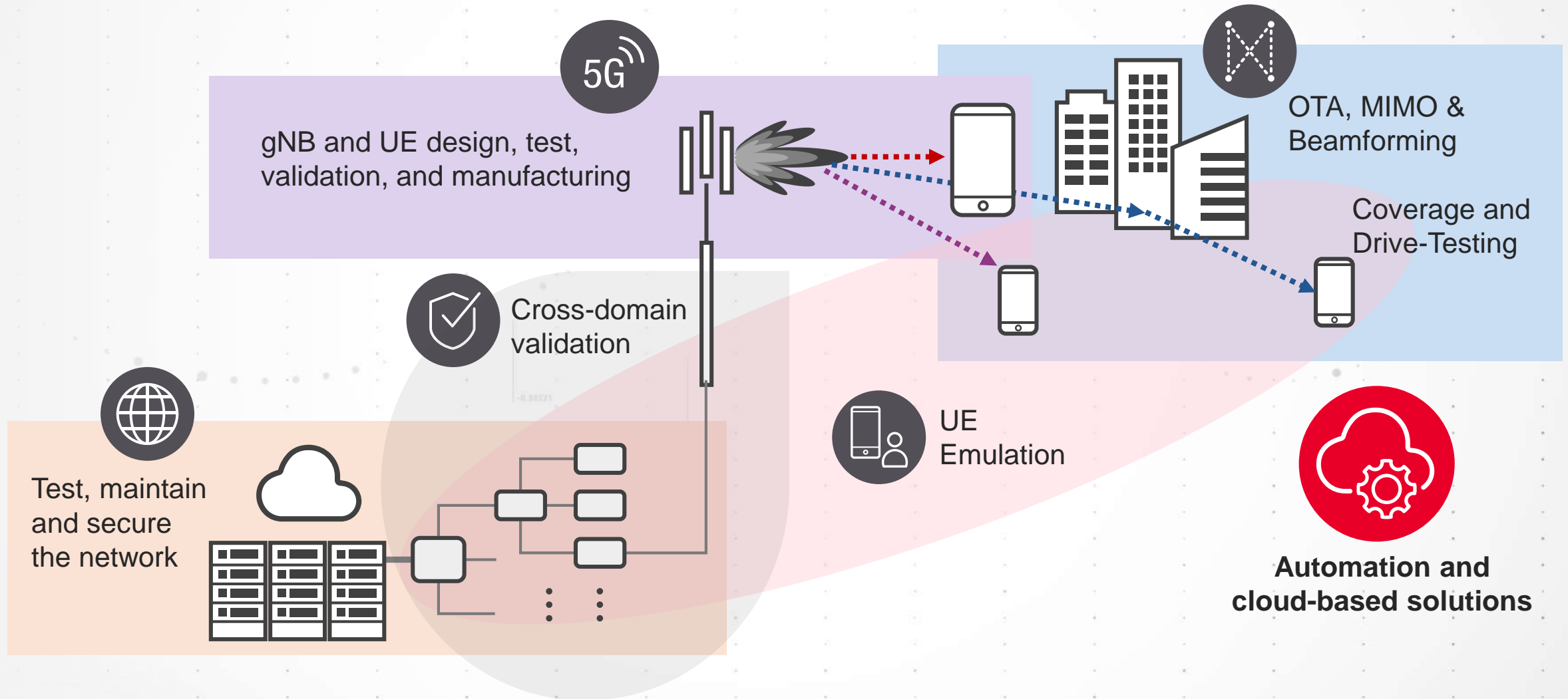
- NSA & SA
- FDD & TDD
- FR1 & FR2





# New Test Strategies Are Needed to Offer New Insights

ACROSS MULTIPLE RF AND PROTOCOL DOMAINS



# **Promise of 5G**

## **New Use Cases and Business Models**

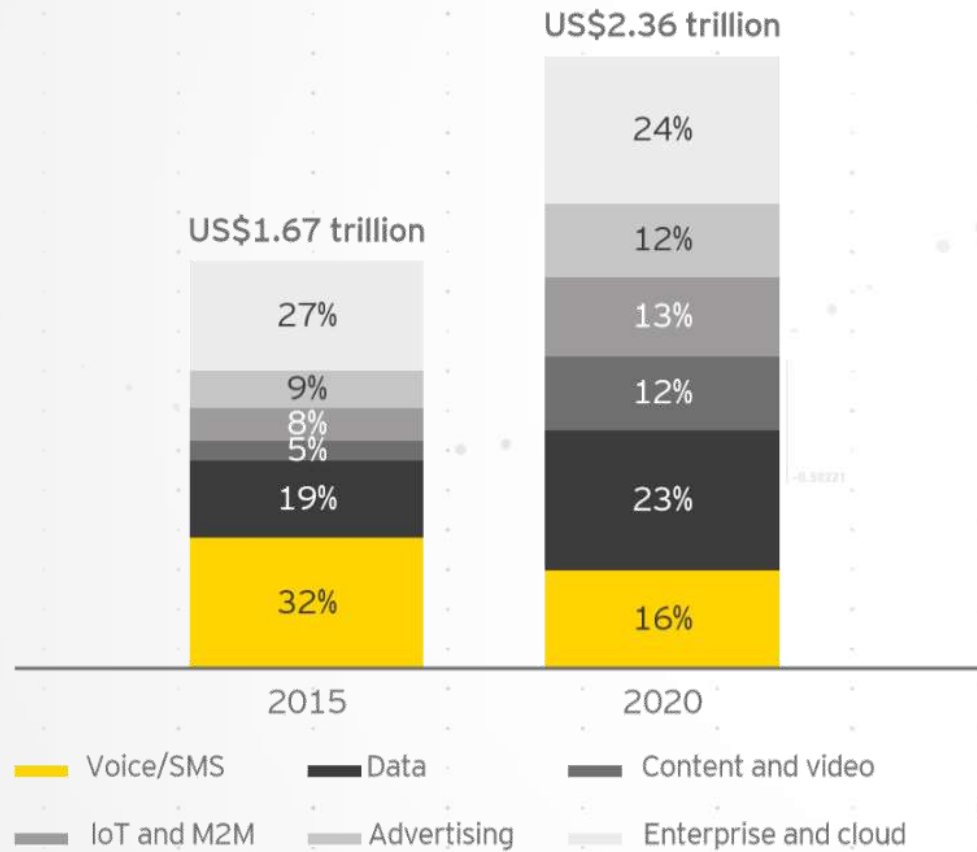




# 5G Enables Newer Business Models

## OPERATORS DRIVE DIGITAL TRANSFORMATION

### Connecting People and Things



Source: Informa, Ovum, GSMA, EY



### Value Added Services

Professional Services



Big Data



Cloud

Connect

#### Network

- Capacity
- Coverage

#### Devices

- eMBB
- Massive IoT

Industry Verticals



Industry 4.0



Healthcare

5G

New value creation

Enable

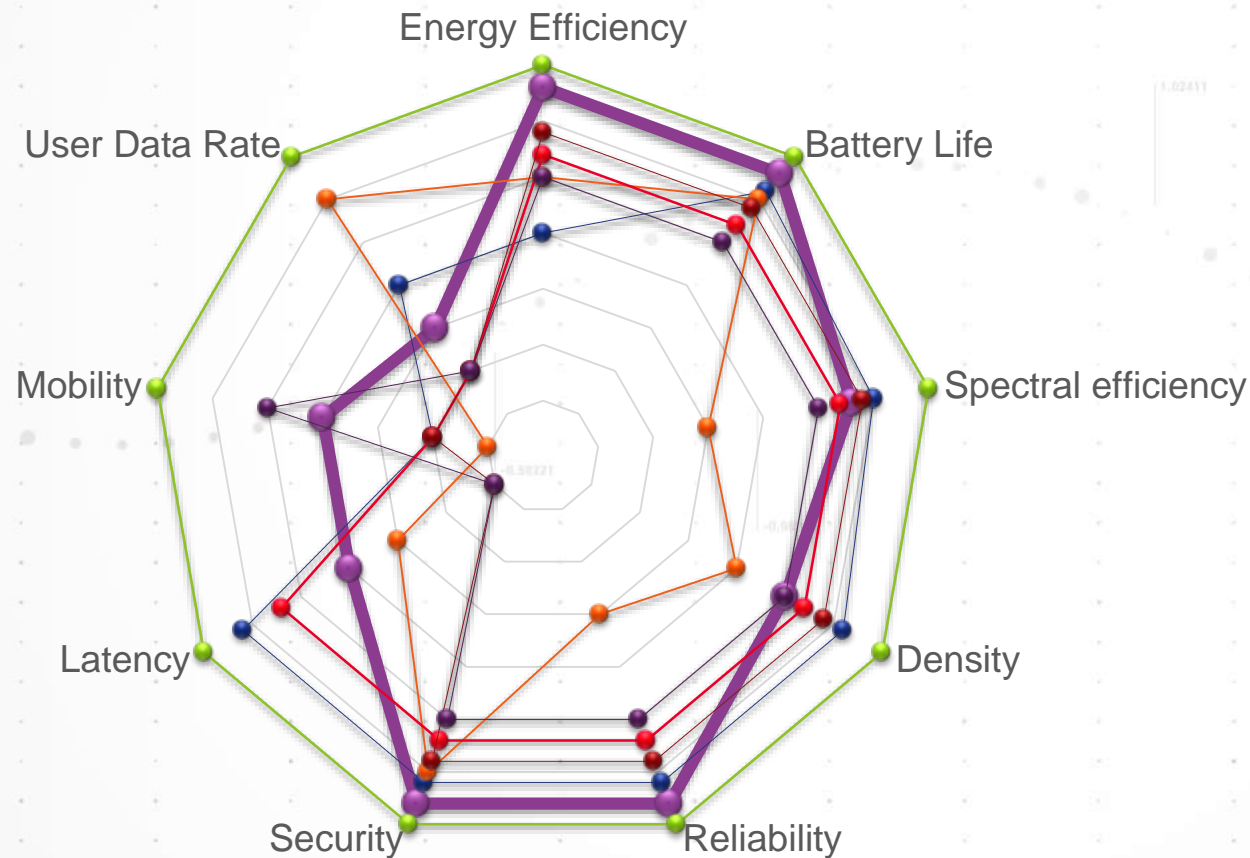
- Ecosystem Orchestration
- Flexible & service based architecture

Transform

- End-to-End Service Provision
- Big Data, Analytics, AI

# Vertical Industry Applications Require Dedicated SLAs

MULTI-DOMAIN KPIS DEFINE QOS AND QOE



**QoS and QoE depend on the cumulative performance of the entire network:**

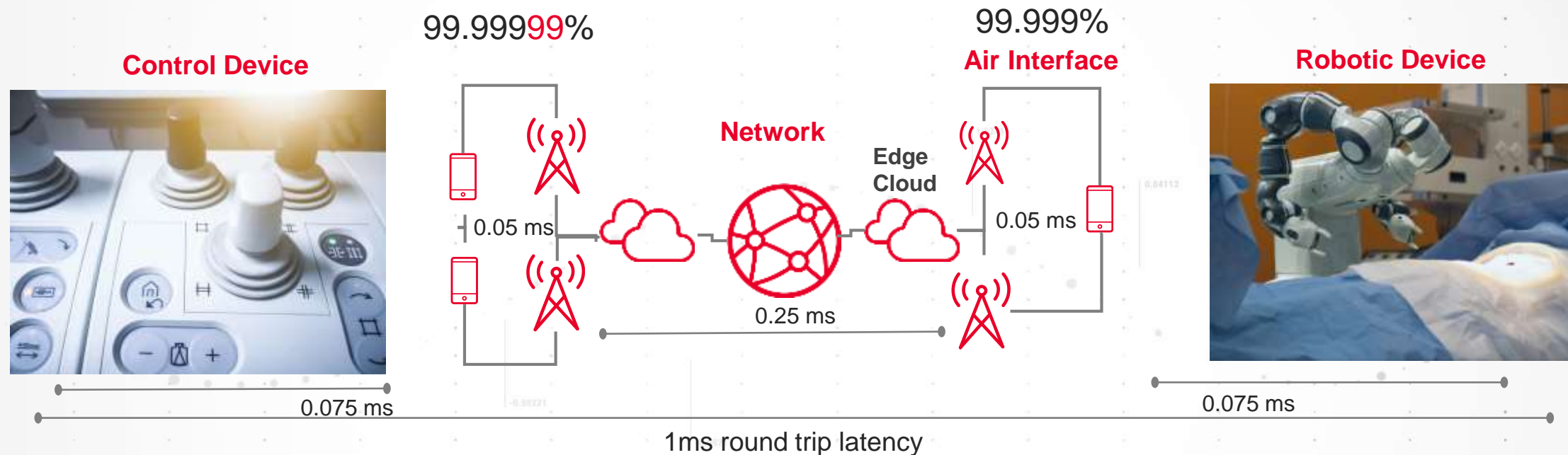
- Devices
- RAN
- Core
- Transport layer
- Cloud

**SLA** – Service Level Agreement  
**QoS** – Quality of Service  
**QoE** – Quality of Experience  
**KPI** – Key Performance Indicator



# Making Remote Surgery a Reality

WITH 5G REDUNDANT CONNECTIVITY, BEAMFORMING & DEDICATED EDGE CLOUD



## QoE

- Instant remote control and haptic feedback
- High definition & real-time audio/video streams
- Extended Battery life for extended surgery time

## QoS

- Near-zero connection downtime
- Minimum packet loss and no video freeze
- Malware and intruder proof

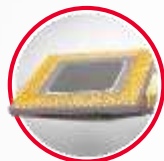
# How does Keysight Enable the Industry?

## Our Role in Making 5G a Reality



# A Comprehensive Solutions Portfolio

COVERAGE OF ENTIRE COMMUNICATIONS INDUSTRY



Components &  
Chipsets



Devices



Base  
Stations



Hyperscale and  
Data Centers



Enterprise

Layers  
2-7

Protocol Design & Acceptance

Field &  
Drive Test

Network Security

Over-The-Air (OTA)  
Test

Key Performance  
Indicators

WiFi Coexistence

Network Monitoring

Beamforming

MIPI<sup>1</sup> Digital Test  
and LP/DDR5

Channel Emulation

Network Loading

mmWave  
Parametric

Circuit Simulators

5G Waveforms

100G / 400G

Gen 5  
PCIe & Memory

Layer 1

Solutions:  Keysight Classic

 Ixia

 Anite

 AT4

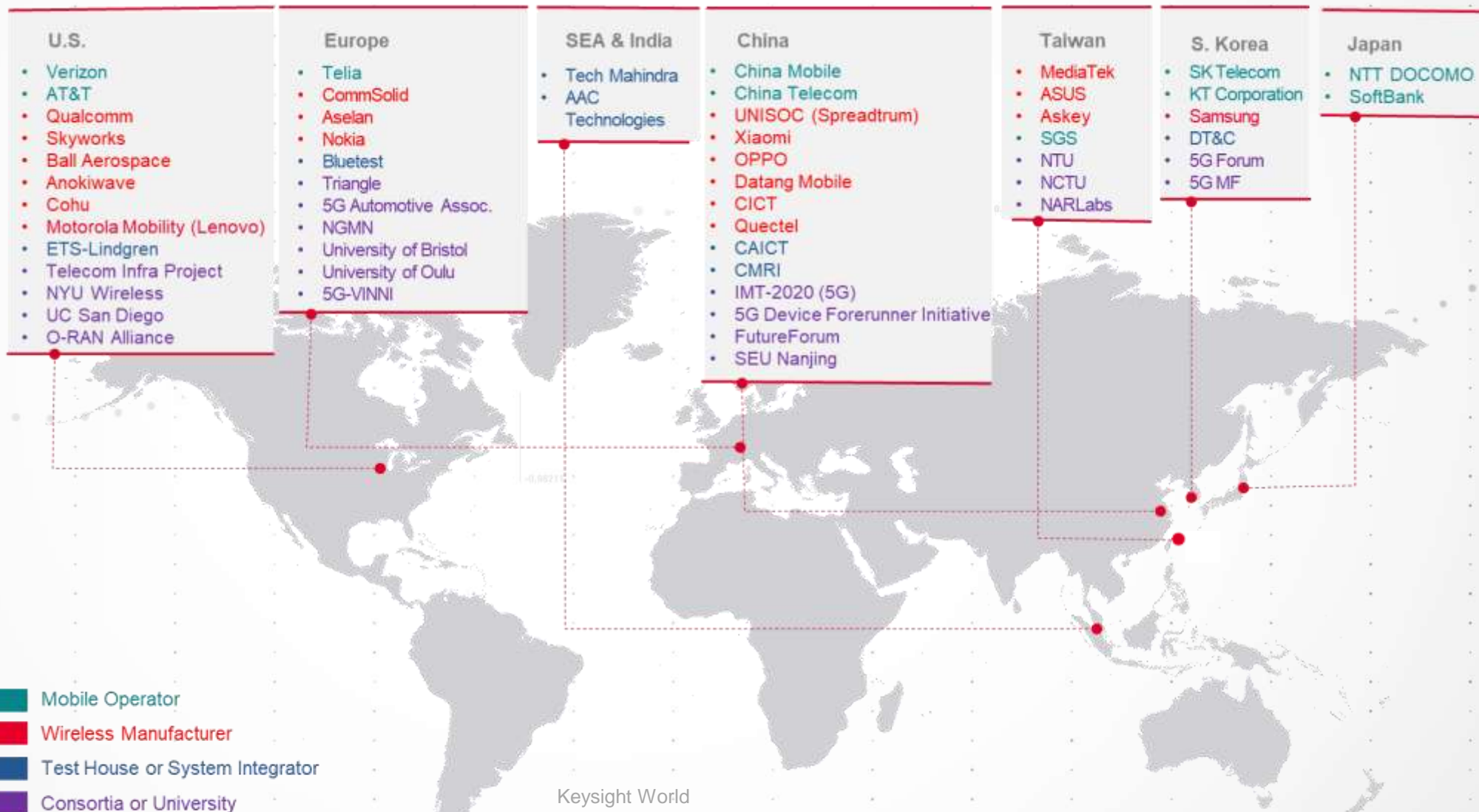
Keysight World



# Extensive Collaborations Around The World

## OUR 5G WORK BEGAN EARLY

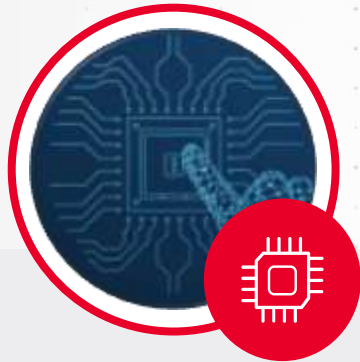
Engaged early with 5G industry leaders across a connected mobile ecosystem



# 5G Solutions – E2E Workflow Based Approach

FOCUS ON ENABLING OUTCOMES

Design  
& Validation



Advanced Design Simulation  
mmWave Test Bed  
Network & UE Emulation

Conformance  
& Acceptance



Protocol Conformance  
RF/RRM Conformance  
Carrier Acceptance

Manufacturing



RFFE / RFIC Mfg.  
Base Station Mfg.  
Device Mfg.

Deployment  
& Operations

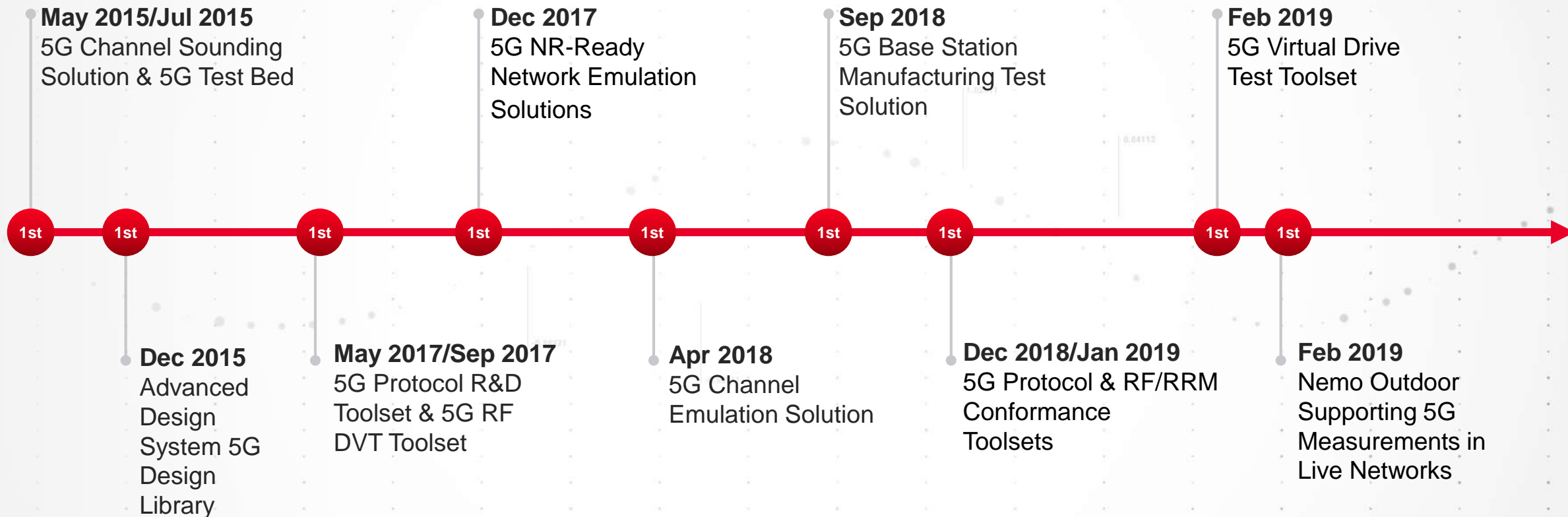


Field Test  
Drive Test  
Monitoring & Security

**PATHWAVE** Connects the Workflow: Open, Scalable, Predictive

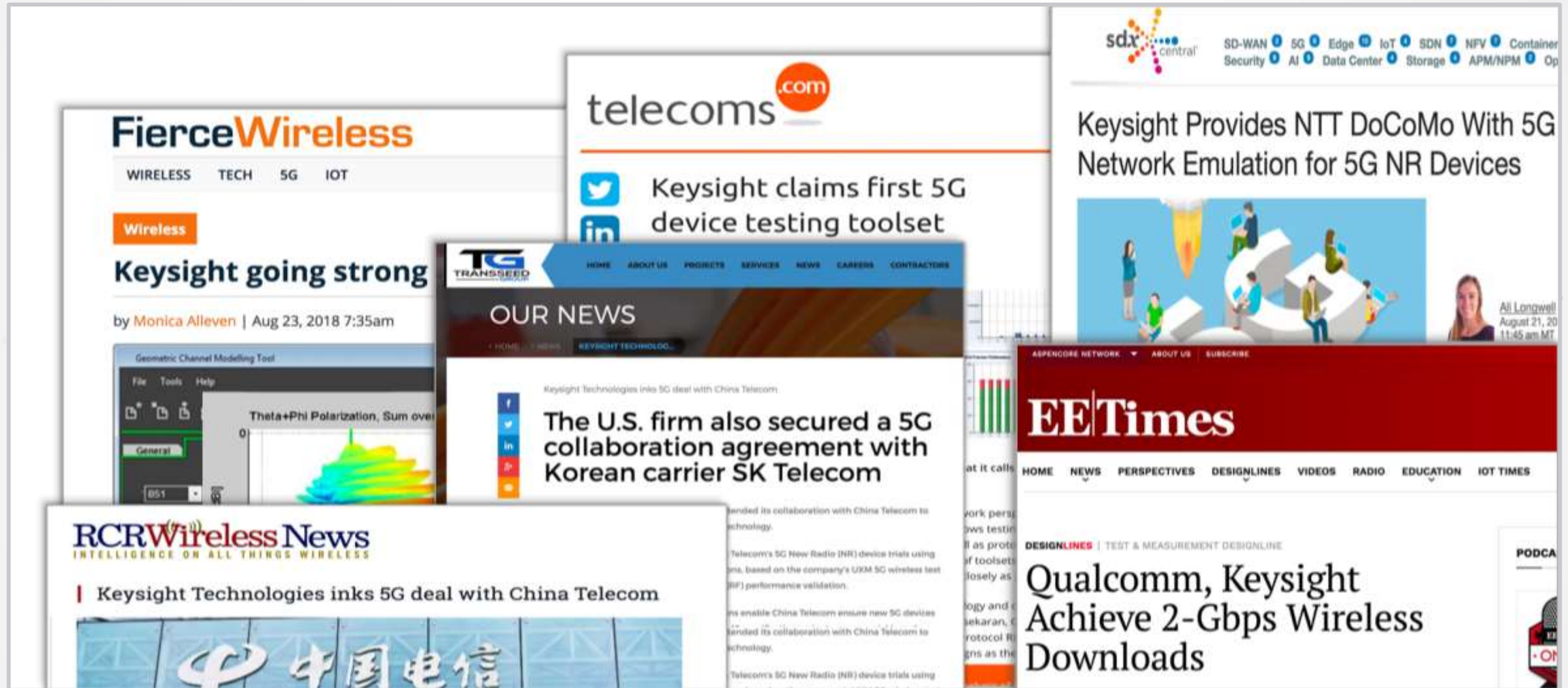
# Keysight's Contributions & Proof Points

## INDUSTRY-FIRST SOLUTIONS






# Enabling Market Leaders







Partner with Keysight and gain market  
leading end-to-end insights to innovate,  
transform, and realize your 5G goals

**Thank you!**





**KEYSIGHT**  
**WORLD 2019**

