5G and the Path to 5G

Oct 19, 2016

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Intel Corporation

5G

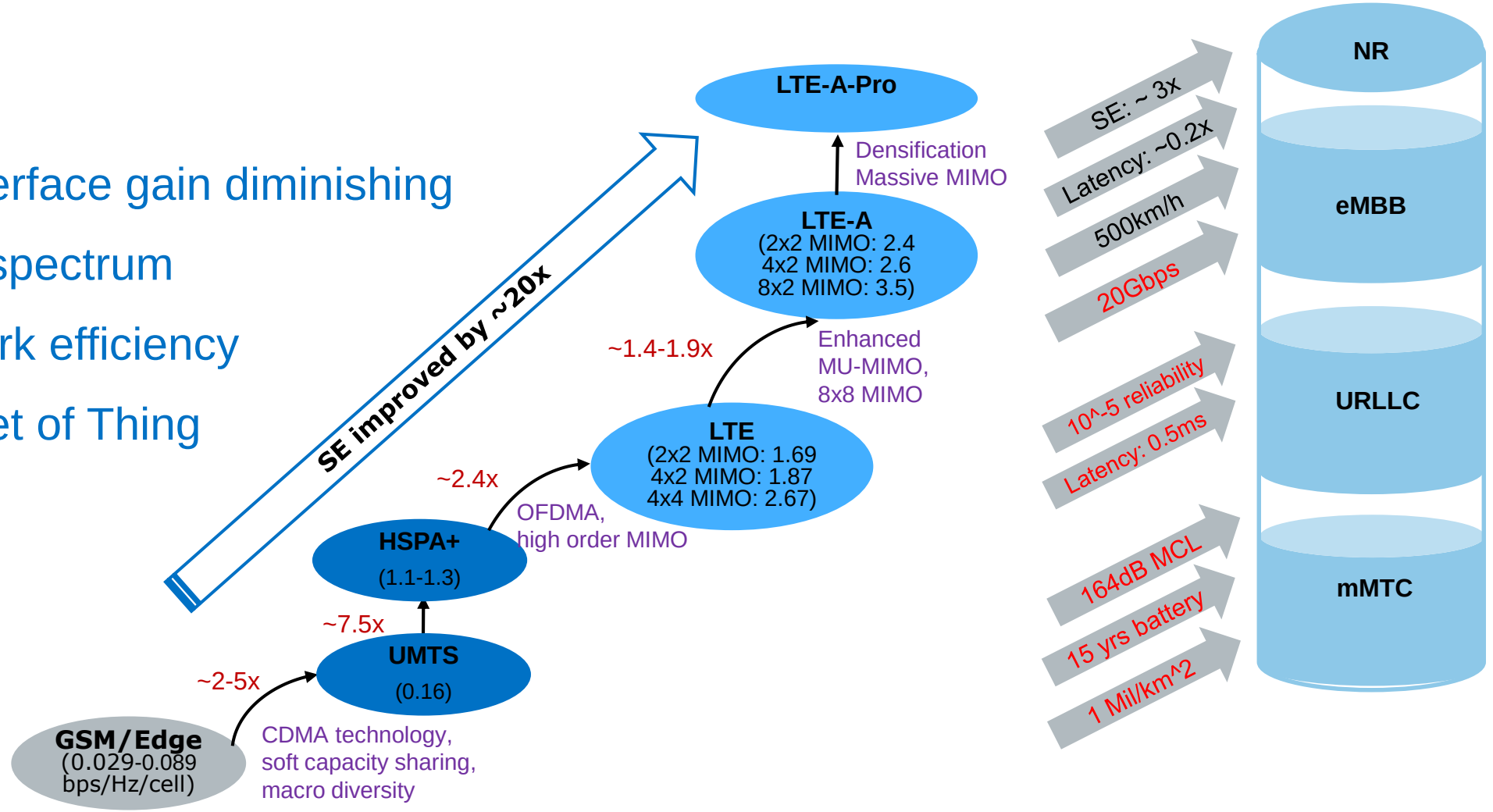
5G Era

Air interface gain diminishing

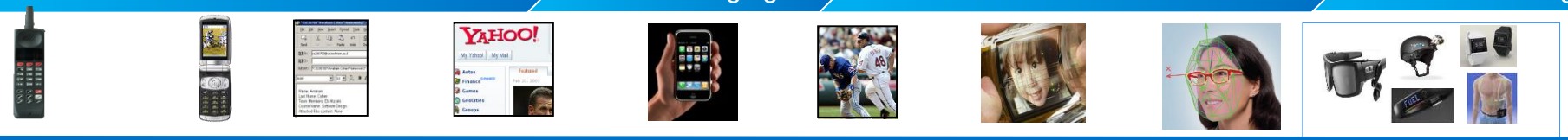
More spectrum

Network efficiency

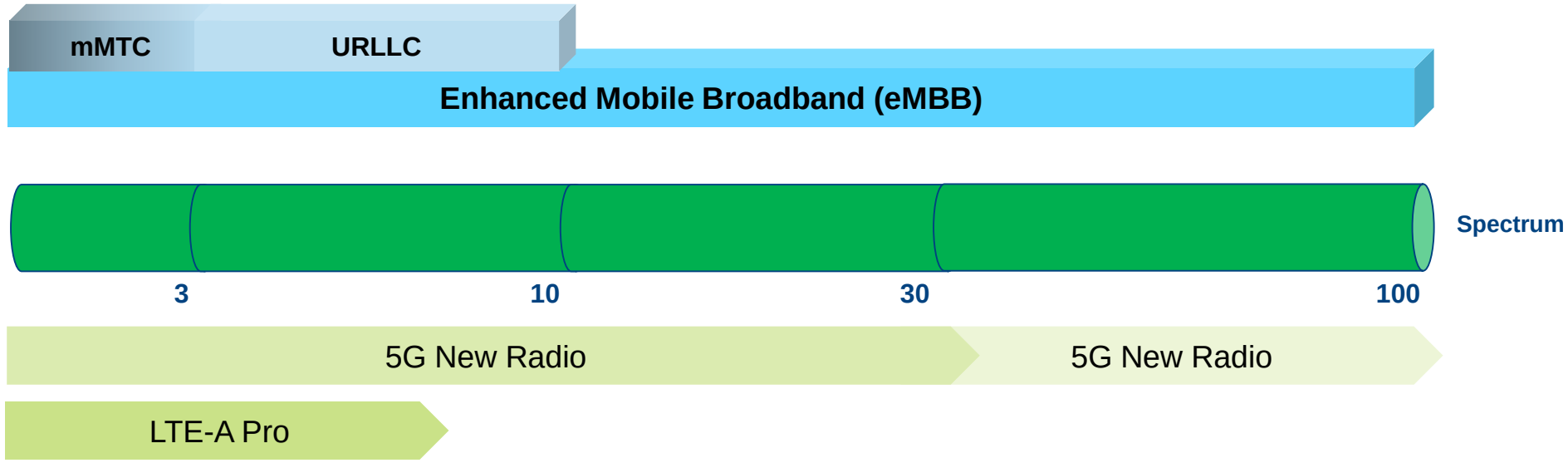
Internet of Thing



Voice centric | Data emerging | True broadband multimedia | Connecting everything



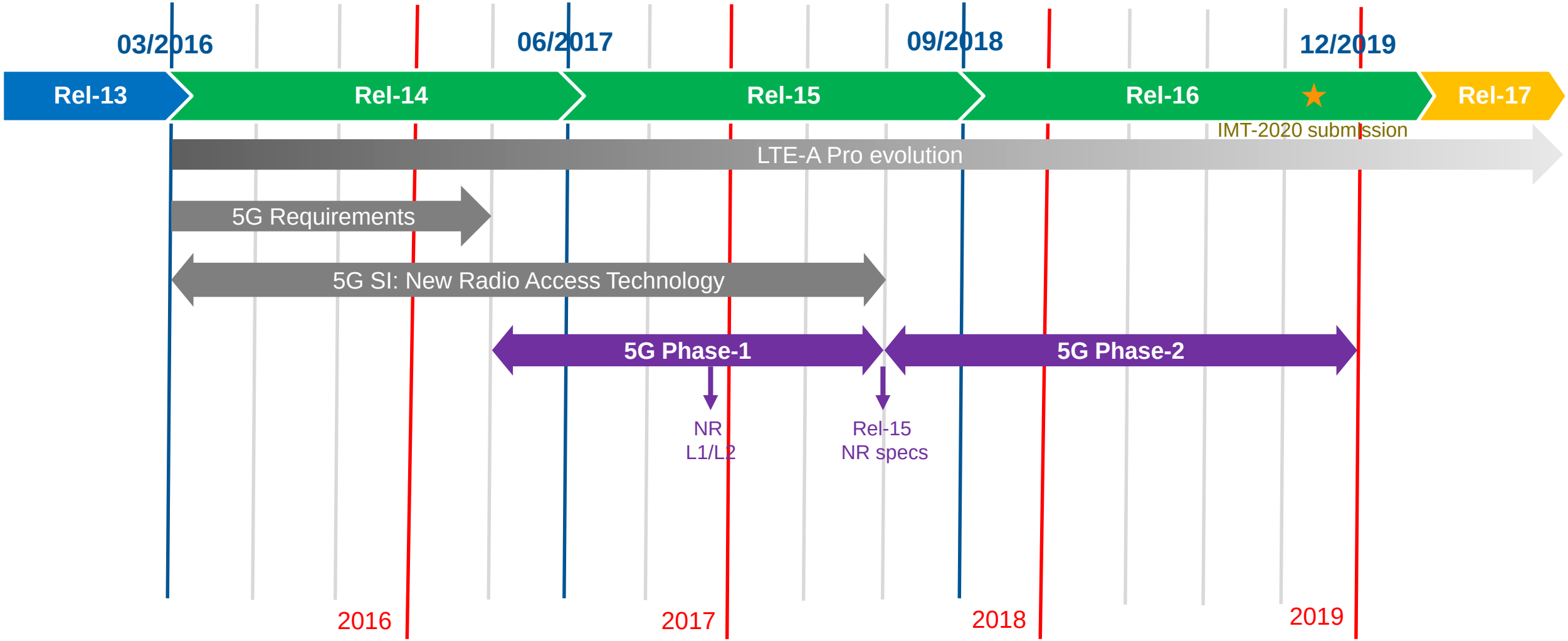
Services and Spectrum in 5G Era



Sub-6GHz to 100GHz with scalable bandwidth

Multi-band and multi-mode support

3GPP 5G New Radio (NR) schedule



3GPP 5G NR Phased-approach

3GPP Release 14/15

5G Phase 1

- Common design covering Sub-6GHz to ~40GHz
- Support eMBB with forward computability to address mMTC and URLLC
  - Delivering Peak Rates of 20Gbps+
- LTE-assisted and standalone operations
- New 5G Core Network (NextGen)

3GPP Release 16

5G Phase 2

- Extend up to 100GHz Spectrum
- Potential new waveforms for mMTC and >40GHz spectrum
- Full support of IMT-2020 and 3GPP NR requirements

5G NR Phase 1: Key Technology Areas

Advanced PHY design:

- Low latency and self-contained subframe design;
- Multiple numerologies for different use cases with efficient in-band multiplexing design;
- Common design across various link directions, UL, DL, sidelink, backhaul, etc;
- Enhanced channel coding and MIMO/beamforming technologies;

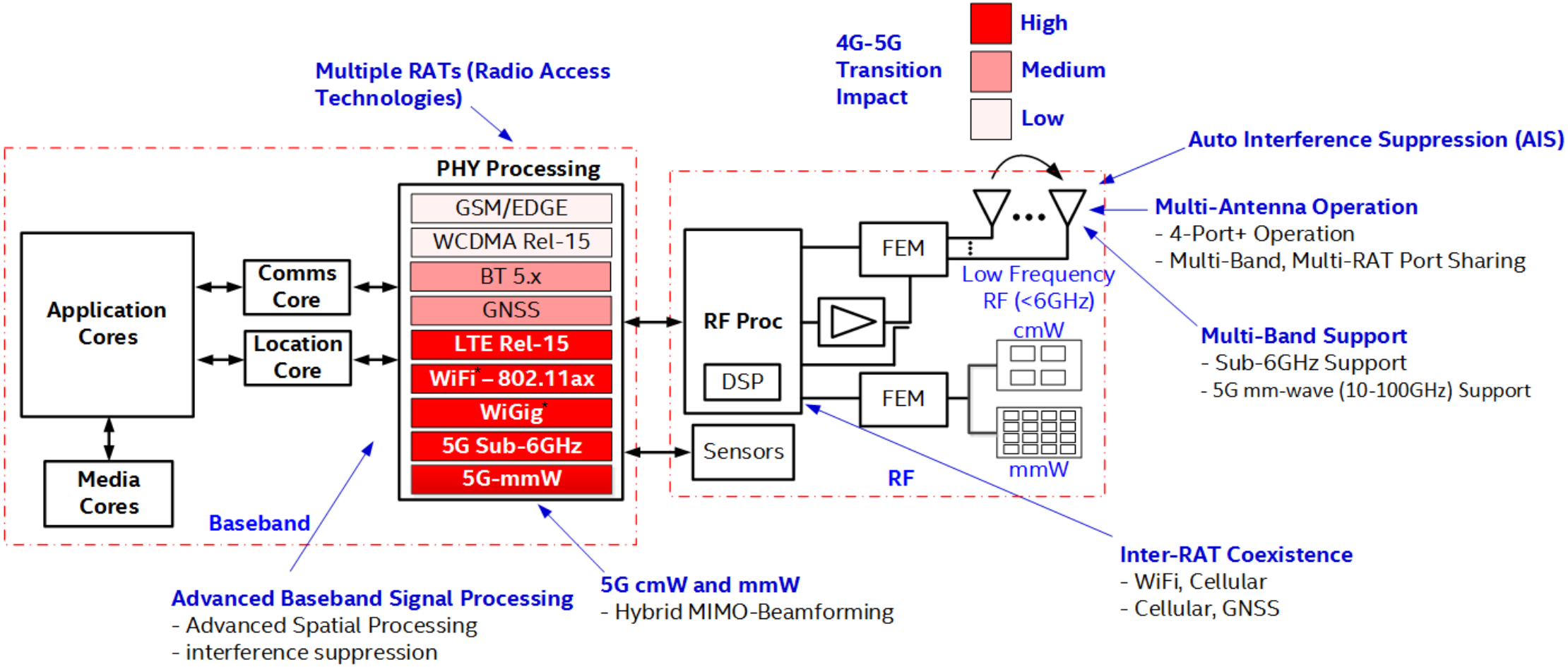
Advance L2/3 protocol design:

- High data rate friendly UP protocol;
- Standalone NR operation;
- LTE-NR tight interworking yet allowing the independent evolution of LTE and NR;
- Power-efficient and signaling efficient mobility handling, as well as optimized intra-5G and inter-RAT mobility;
- Flexible QoS handling;

The Path to 5G

5G Device Implementation

Baseband and Stack Technology



Technical Viability – Silicon Performance

Manufacturing

14 nm

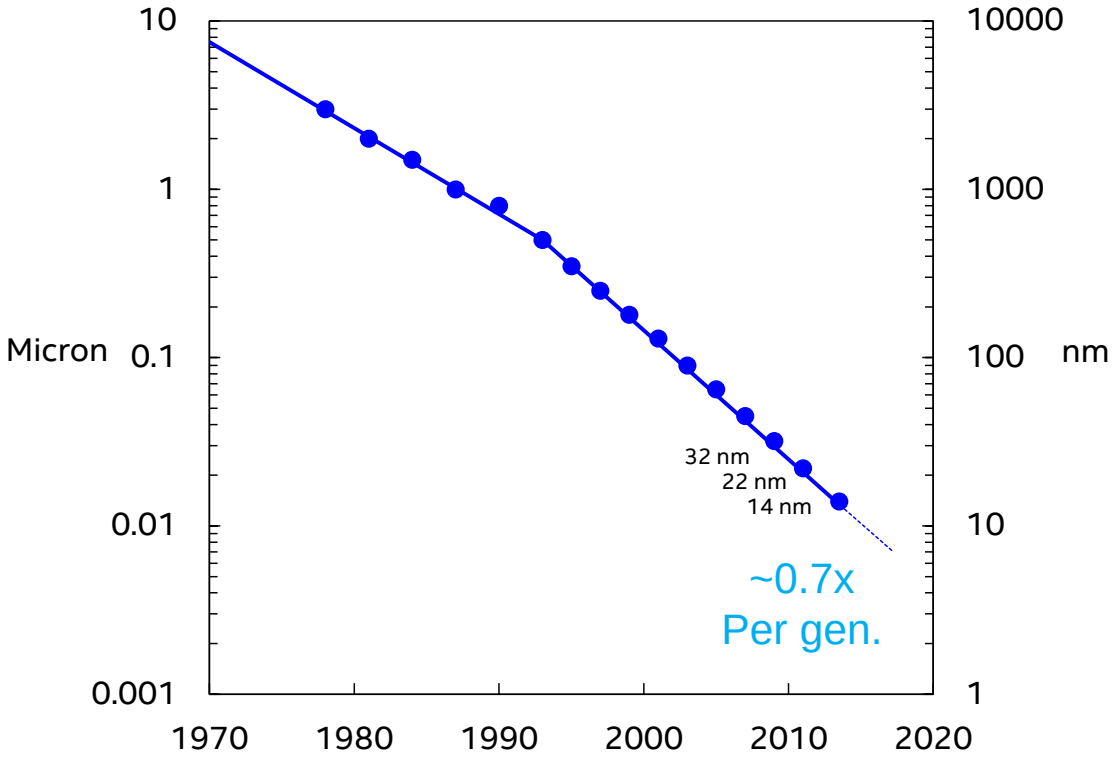
Development

10 nm

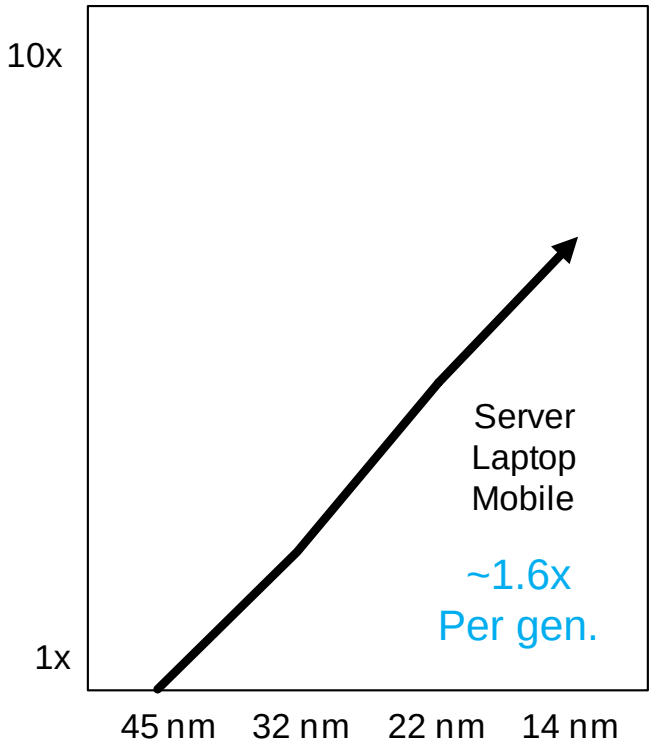
Research

7 nm

Process Node Maturity



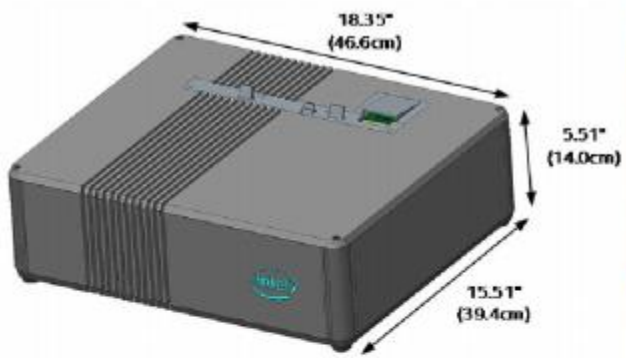
Transistor Scaling

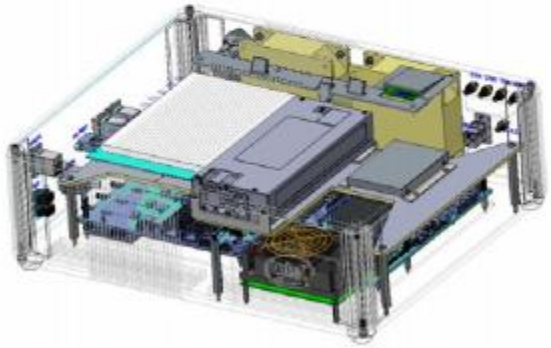


Performance Per Watt

Advances in Process Technology Point to 5G Era Performance

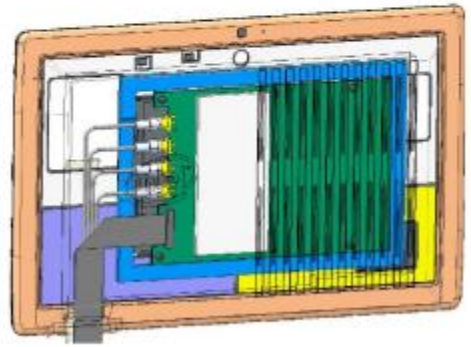
Intel 5G Mobile Trial Platform (5G-MTP)





5G Modem Chassis
2nd Generation

Skylake Mounted in 5G
Modem Chassis



28GHz and 4GHz Antennas
Mounted on Rear of Skylake

5G-MTP Phase1.0 Baseband

Altera Arria 10 FPGA (5x)

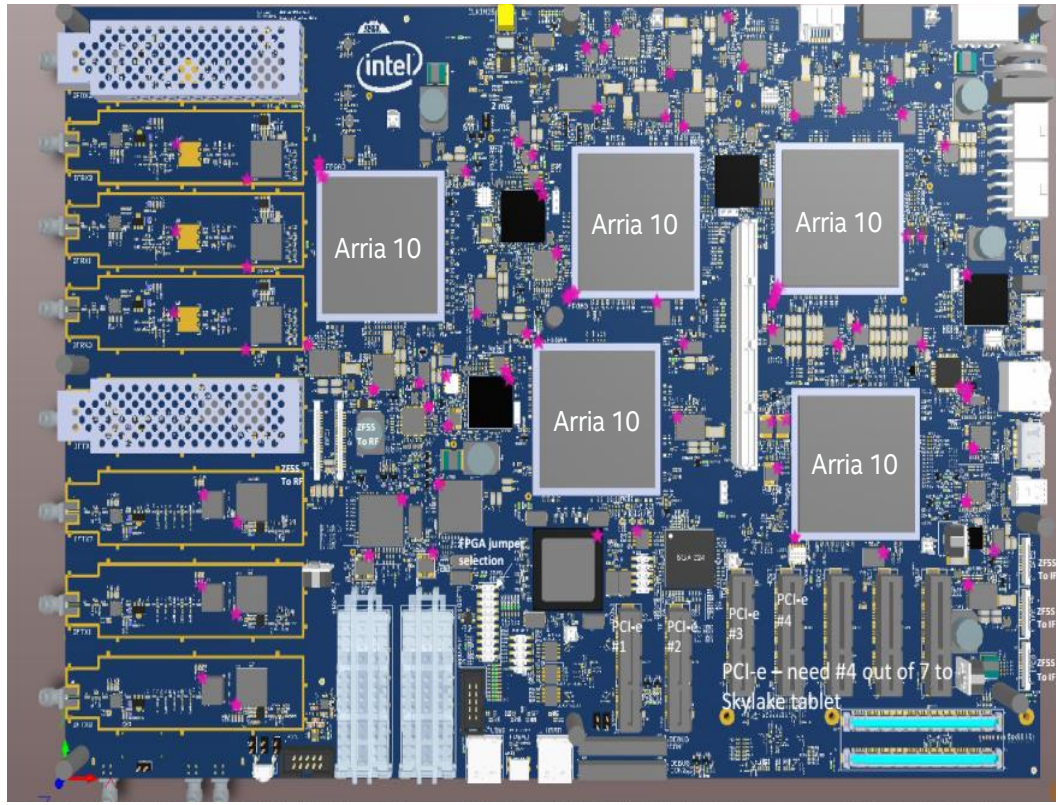
800MHz RF bandwidth

Sub-6GHz and mmW Support

- 3.4-5.9GHz
- 26.5-29.5GHz

Compliant to 5GTF V5G specs & Track 3GPP NR

- Low latency self-contained subframe structure
- Advanced channel coding
- Advanced beamforming
- Support LTE-assisted and standalone operations



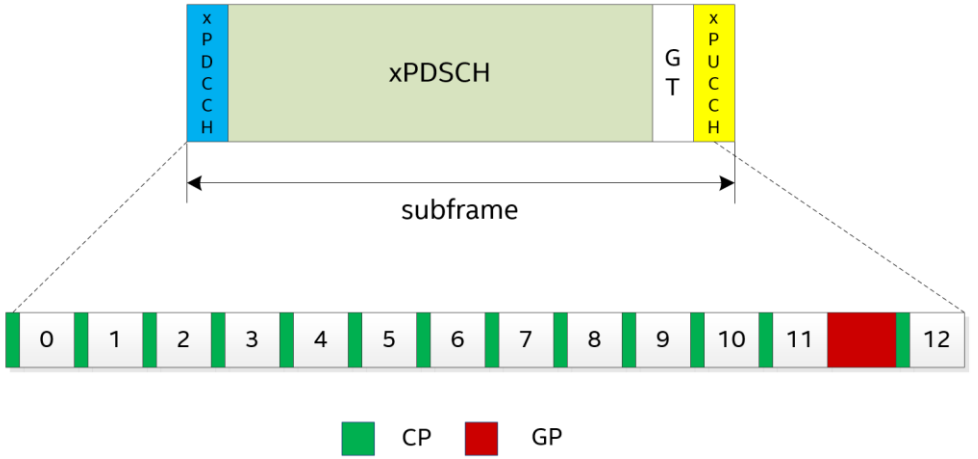
Baseband Features

Parameter	Value
Carrier Bandwidth	100MHz
Waveform	OFDM
Sampling Rate	153.6MHz
Subcarrier Spacing	75kHz
Symbol Duration	13.3us
OFDM Symbols per TTI	14
CP Length	0.94/1.04us
TTI Length	0.2ms
Radio Frame Duration	10ms

Numerology Example

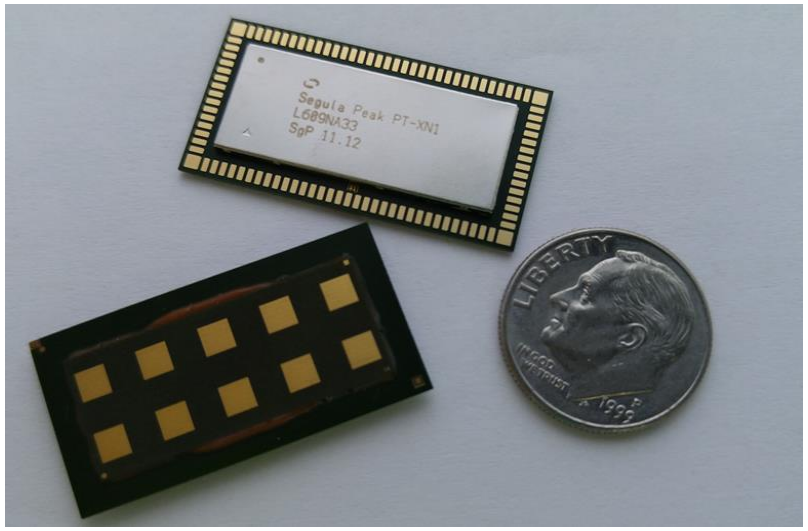
Parameter	Value
Peak Rate (DL) – UE	3~10Gbps
BS-UE Delay RTT	2ms

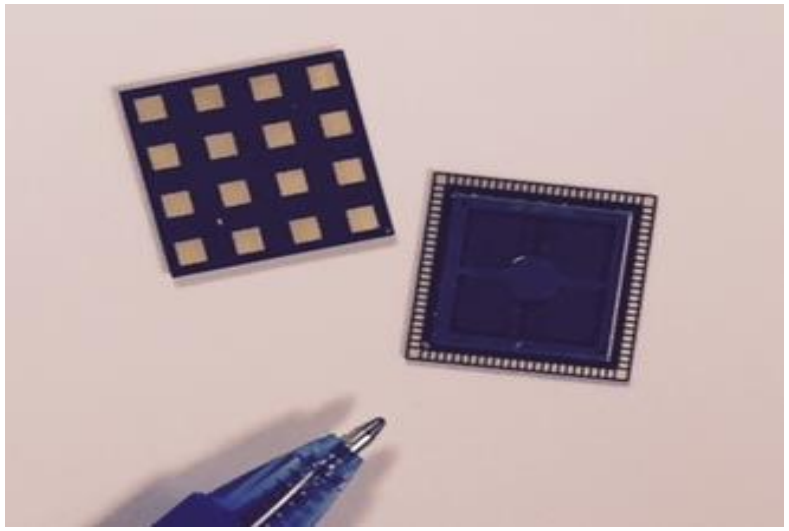
Primary Performance

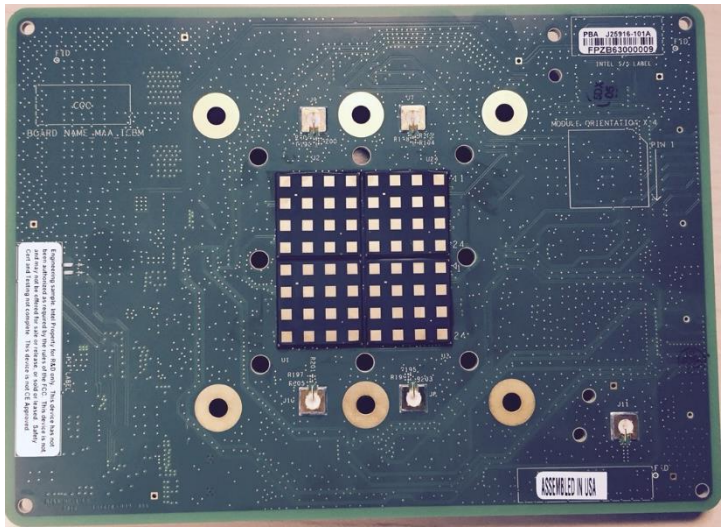


Frame Structure

5G 28GHz RFIC



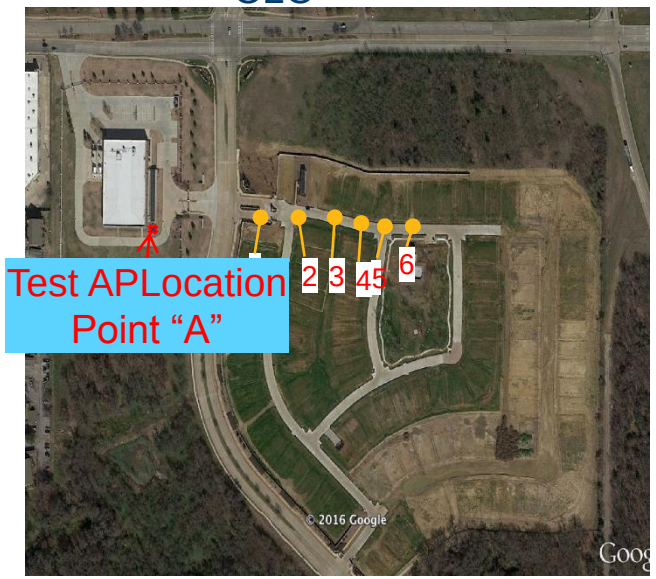




mmWave RF IC Feature	Details
RF Bands	26.5 – 29.5 GHz
Max Number of Tx/Rx	8/8 (4x2 ant array) 16/16 (4x4 ant array) 64/64 (8x8 ant array)
RF BW	up to 800MHz
Polarization	H & V

Field Trial At a Glance

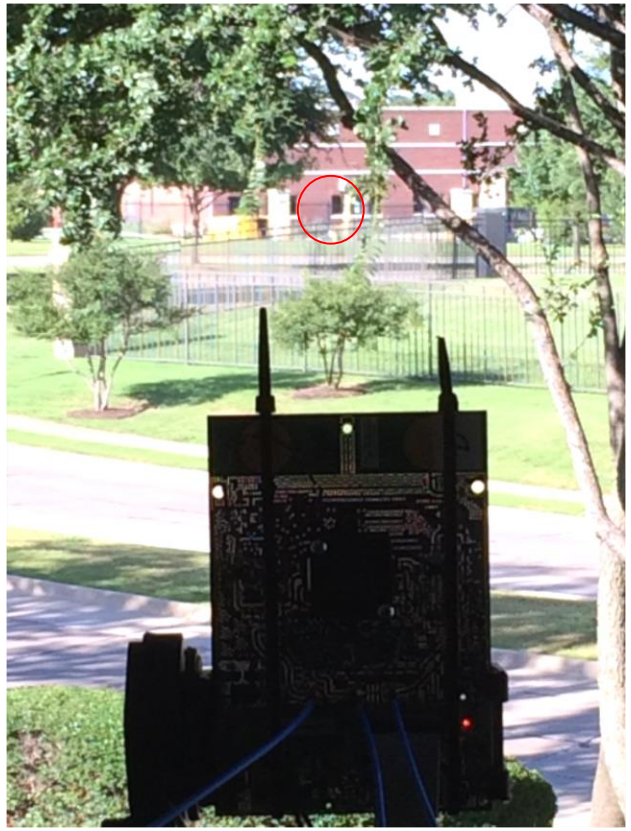
O2O



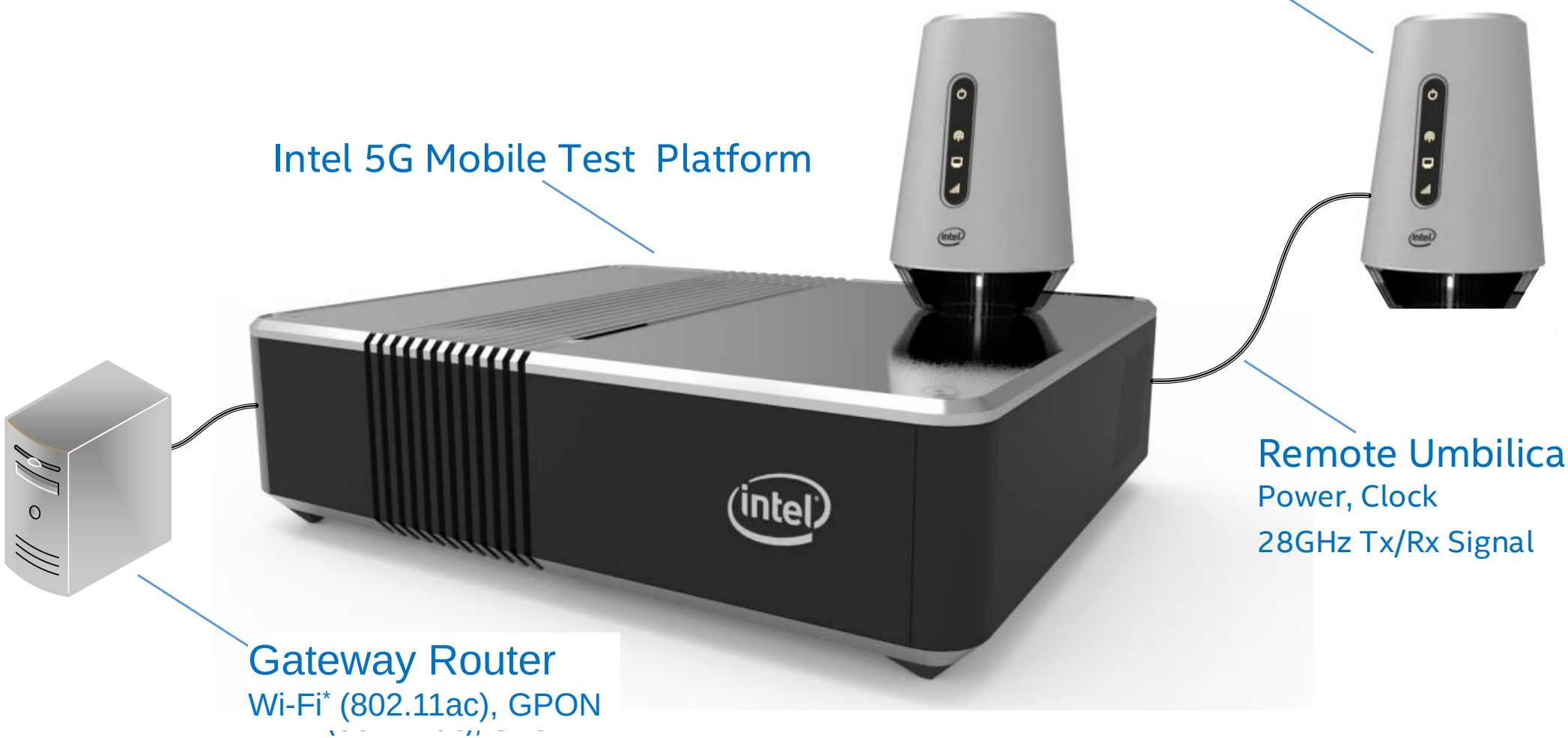
Beam angle

Material Obstruction

O2I



28GHz 5G-MTP: CPE Variant



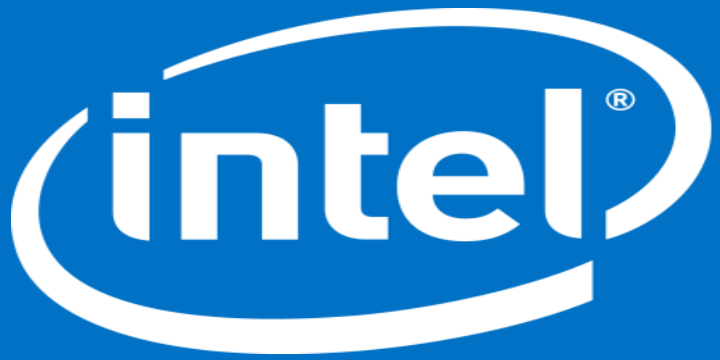
Summary and Outlook

5G Era – Forward compatible unified system design to support all services in 5G era

Frequency Bands – Both sub-6Hz and mm-wave bands key

Technical Viability – Process node technology placing 5G within reach

Timing – On track for 2017 fixed wireless and 2020 3GPP NR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