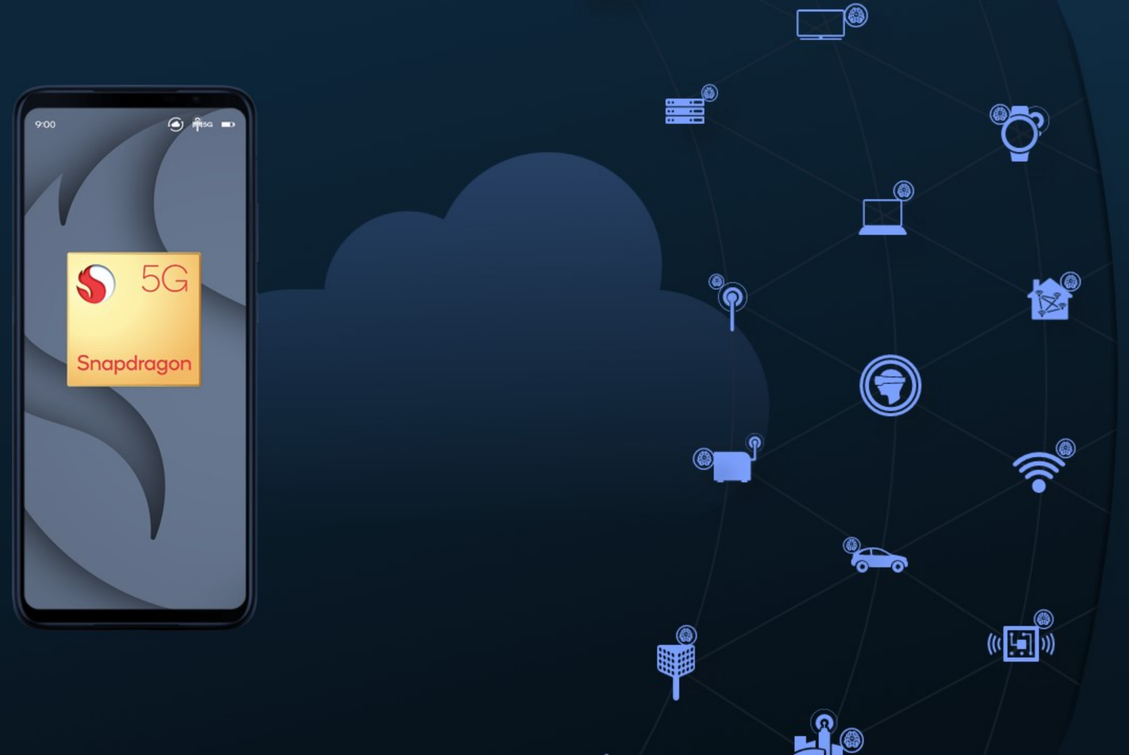
Qualcomm

Dr. James Thompson

Chief Technology Officer, Qualcomm Technologies, Inc.

@qualcomm

Technology leadership extended to the edge

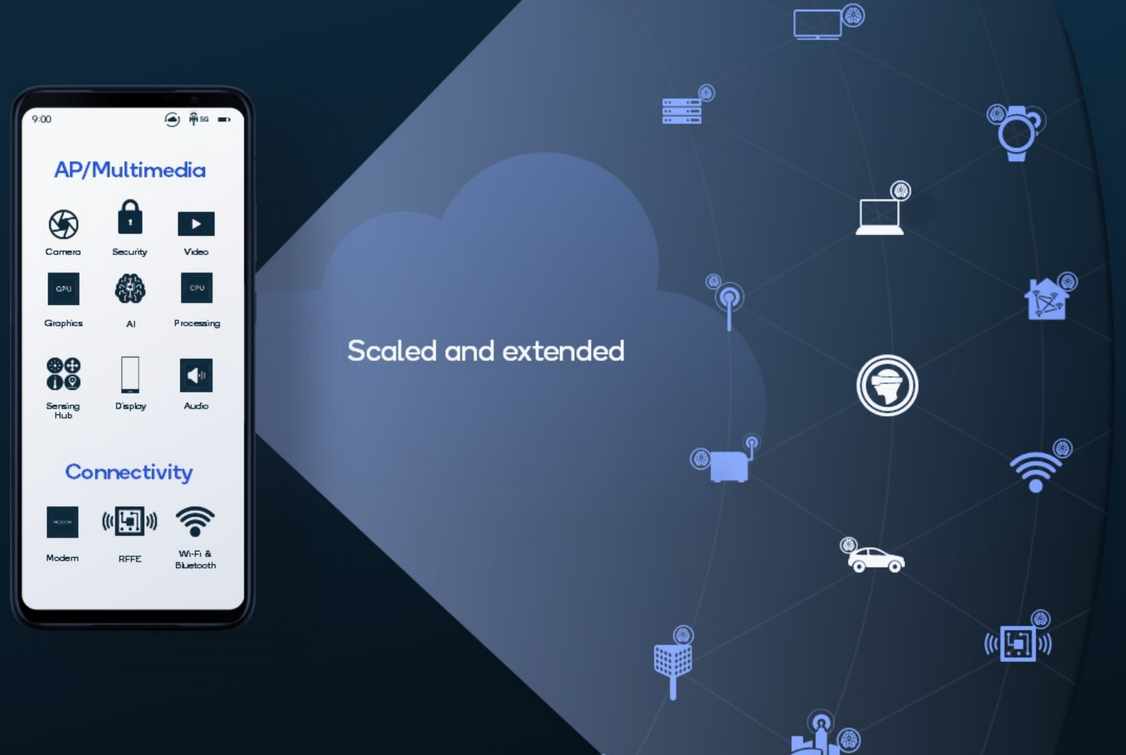


Owning and leading key technologies

One technology roadmap that scales across all end-market requirements

Snapdragon is a product of Qualcomm Technologies, Inc. and/or its subsidiaries

One technology roadmap



Connected intelligent edge

We have the essential technologies for mobile and the connected intelligent edge

Edge AI

Camera

Graphics

Processing

Connectivity

We control the roadmap that is driving digital transformation


Edge AI
Camera
GPU
Graphics
CPU
Processing
Connectivity

Center of gravity of AI processing is moving to the edge

Privacy

Reliability

Immediacy

Autonomy

Efficiency

Personalization

5G

Training data

Maps
Upgraded models

5G V2X wireless sensor

3D HD maps

Precise positioning

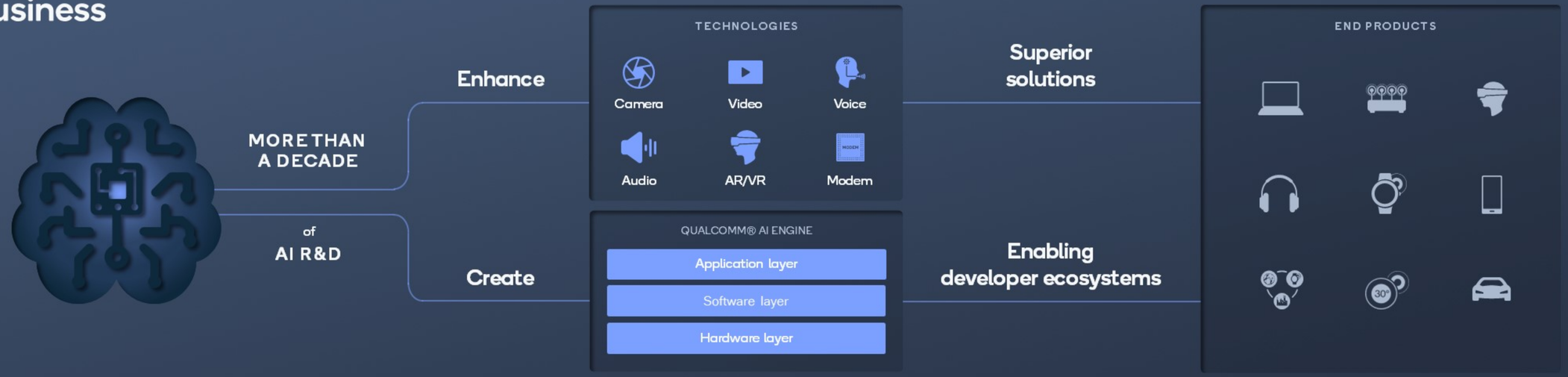
Car makes local decisions

Latency

Reliability

Efficiency

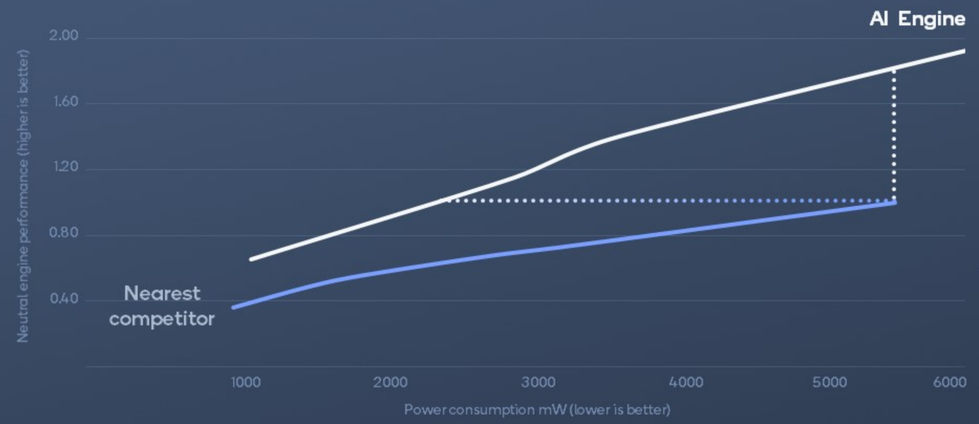
We apply AI broadly across our business



Qualcomm AI Engine is a product of Qualcomm Technologies, Inc. and/or its subsidiaries

AI focus: Energy efficient computation

Neural engine performance vs. power



Up to **1.8x** Faster neural engine performance at the same power

Matches peak competitor performance using <50% of the power

Source: Internal analysis and testing. 1. For a quantized INT8 model vs a FP32 model that is not quantized; 2. With both Bayesian compression and spatial SVD with ResNet18 as baseline; 3. On average improvement of tested AI models; 4. Our DONNA NAS vs state-of-the-art

Up to 16x	Performance per watt improvement with savings in memory and compute from quantization[1]
3x	Compression with less than 1% loss in accuracy[2]
2–4x	Compilation performance improvement over TensorFlow Lite[3]
20–40%	Lower latency at similar accuracy with NAS[4]

Edge AI requires support for all key ecosystems across markets

TensorFlow | mxnet | ONNX | PyTorch | Caffe | Caffe2 | PaddlePaddle

Tools/compilers: AIMET TVM

Models: ResNet SSD MobileNet BERT VDSR DeepLab

Qualcomm® Neural Processing SDK | TensorFlow Lite | Android Neural Networks API | WinML

Qualcomm® AI Engine direct | NNAPI

Qualcomm Neural Processing SDK and Qualcomm AI Engine direct are products of Qualcomm Technologies, Inc. and/or its subsidiaries; AIMET (AI Model Efficiency Toolkit) is a product of Qualcomm Innovation Center, Inc.

Edge AI

Camera

Graphics

Processing

Connectivity

Snapdragon raises the bar in camera quality year over year

DXOMARK

Camera quality benchmark lab

#1

2019

Xiaomi Mi CC9 Pro Premium Edition

121 score

#1

2020

Oppo Find X2 Pro

124 score

#1

2021

Xiaomi Mi 11 Ultra

143 score

Designed for #1

2022

Next-gen Snapdragon

Source: DXOMARK
Number one on first appearance in DXOMARK rating

Snapdragon raises the bar in camera quality year over year

DXOMARK

Camera quality benchmark lab

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2021

Xiaomi Mi 11 Ultra

143 score

Designed for #1

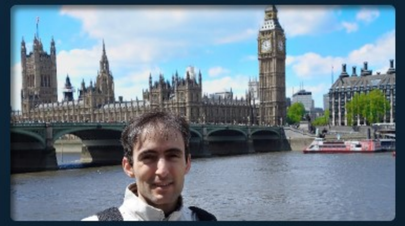
2022

Next-gen Snapdragon

Source: DXOMARK
Number one on first appearance in DXOMARK rating

AI makes our camera even better

Contextual awareness

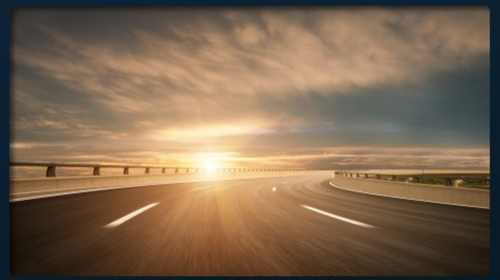


Snapdragon low-light video capture enhanced by AI

Source: Video courtesy of Jiigan Technology

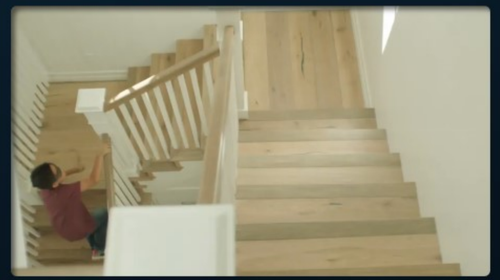
Extending and scaling our camera technology across markets

Dense optical flow

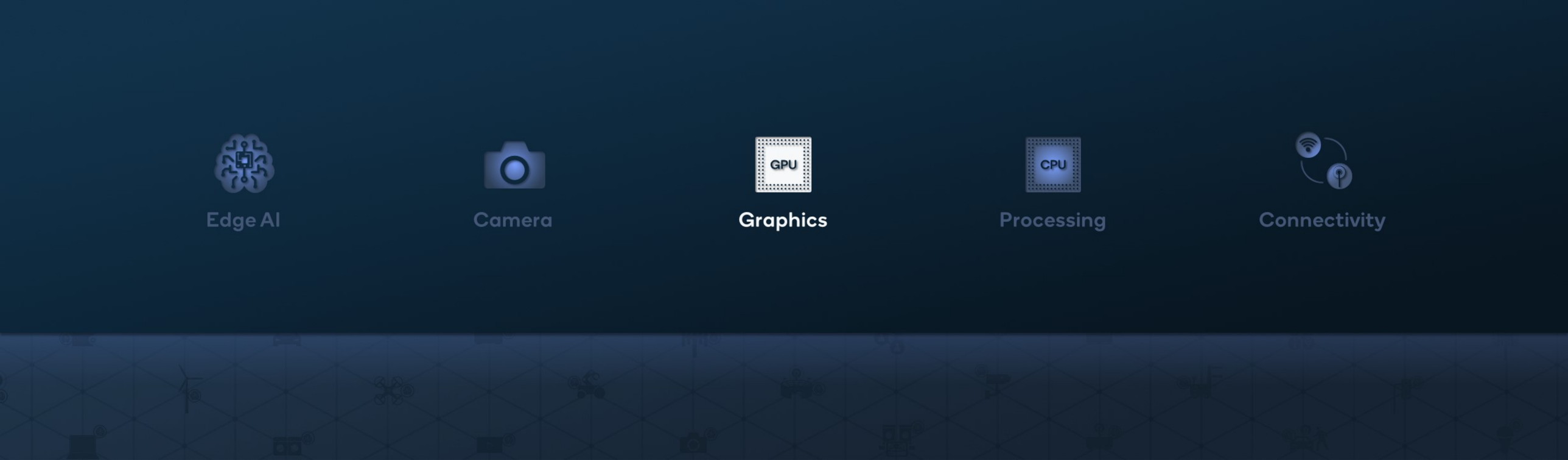


24-bit HDR

Eye tracking

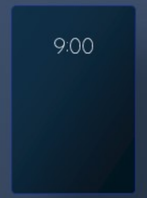


Room scale


Edge AI
Camera
GPU
Graphics
CPU
Processing
Connectivity

3.5+ Billion

Qualcomm® Adreno™ GPUs shipped across smartphones, PCs, tablets, cars and IoT devices



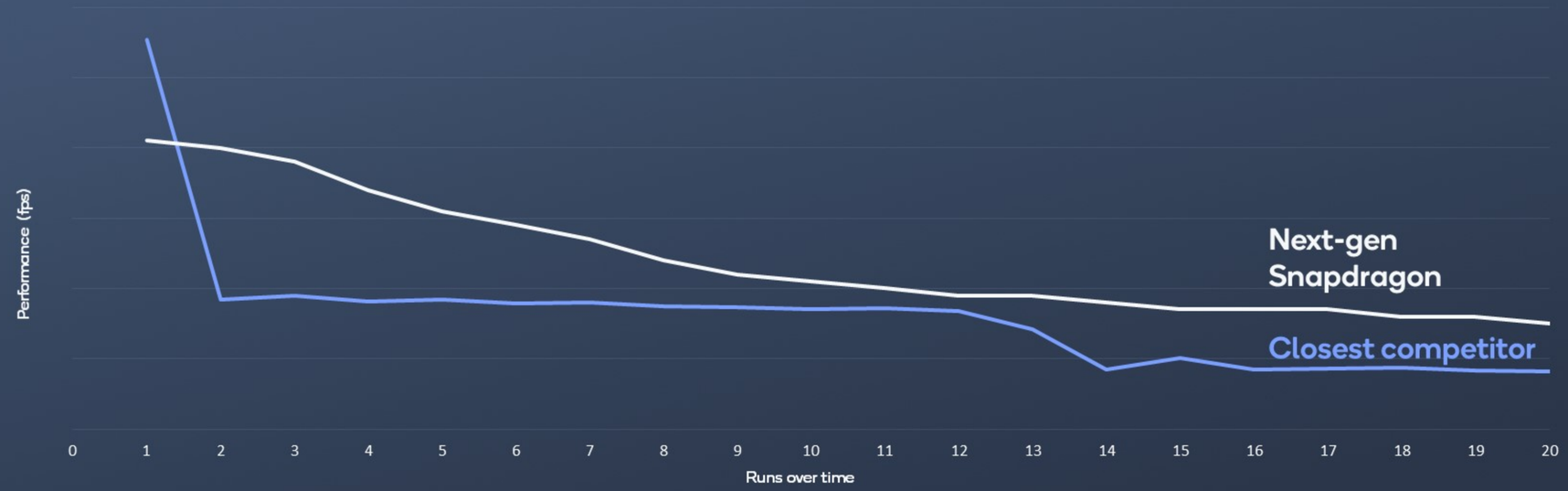
Fully scalable with large opportunity for continued growth

- Best-in-class performance per watt
- Best sustained gaming performance
- Scalable from super low-power to highly demanding

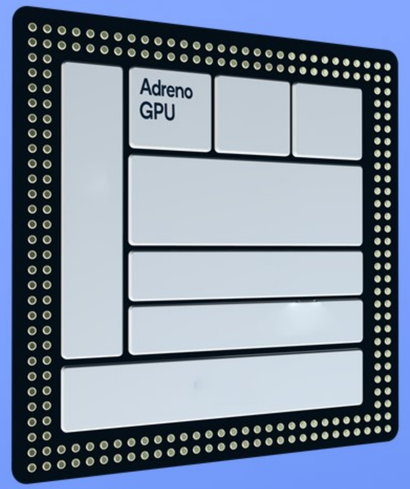
Source: Internal data and analysis

Qualcomm Adreno is a product of Qualcomm Technologies, Inc. and/or its subsidiaries

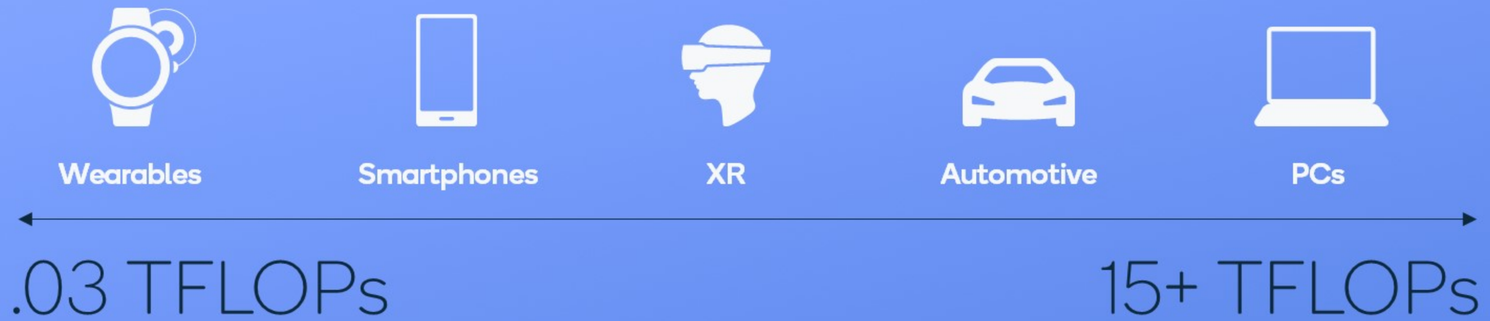
Better sustained graphics performance compared to closest mobile competitor



Source: Internal testing using Aztec Ruins normal 1080p offscreen (20 runs)



Adreno GPU scales to serve different markets




Edge AI
Camera
GPU
Graphics
CPU
Processing
Connectivity

Next-generation CPU leadership

Arm-compatible CPU designed by Nuvia team

M-series competitive solution for the PC

Designed to set the performance benchmark for Windows PCs

Leadership in sustained performance and battery life

Will be extended to mobile, automotive and data center opportunistically

Sampling to customers in 2022 for devices launching in 2023


Edge AI
Camera
GPU
Graphics
CPU
Processing
Connectivity

Industry-leading

connectivity

Technology ownership allows for fast adoption of new features and performance enhancements

5G

Wi-Fi

Bluetooth

GNSS / Location


Qualcomm leads evolution of 5G
Enhanced mobile broadband services (eMBB)
5G core network and enhanced E2E security
Sub-6 GHz with massive MIMO
Advanced channel coding
3GPP Release 15
Scalable OFDM-based air interface
Mobile mmWave
Flexible framework
LTE integration
5G broadcast
In-band eMTC/NB-IoT and 5G Core
5G NR in unlicensed spectrum
Positioning across use cases
Better coverage with IAB, uplink MIMO
Release 16
2021
Dual connectivity, mmW/sub-6 aggregation
Private networks, industrial IoT
Mission-critical services with eURLLC (e.g., 5G NR IIoT)
IAB integrated access/backhaul
5G NR cellular V2X
Enhanced DL/UL MIMO, multiple transmission points
Enhancements to 5G NR industrial IoT
Expand sidelink for V2X reliability, P2V, IoT relay
Unlicensed spectrum across all use-cases
New spectrum above 52.6 GHz
Release 17
~1.5-2 YEARS BETWEEN RELEASES
Centimeteraccuracy industrial IoT with mmWave
More capable, flexible IAB
NR-Light Reduced Capability (RedCap) for low-complexity IoT
Non-terrestrial network (i.e., satellites)
Rel-15 deployment learning, eMBB enhancements, XR, others
Further eMBB enhancements
Broadcast enhancements
5G NR-Light expansion for IoT
Smart repeaters for coverage expansion
Automotive and NR V2X enhancements
Release 18+ 5G Advanced
AI/ML data-driven designs
Extended reality (XR)
Full-duplex MIMO
Sidelink in unlicensed spectrum
Non-terrestrial network enhancements
Enhancements for smartphones
Enablement of new device types
New service opportunities

Our 5G Modem-RF portfolio supports every network in the world

Addressing massive RF complexity

10K+

Band combinations possible[1]

Global reach and scale

180

Operators[2]

40+

Handset OEMs[3]

30+

Non-handset OEMs[3]

Mature modem-RF roadmap

4th gen 5G baseband

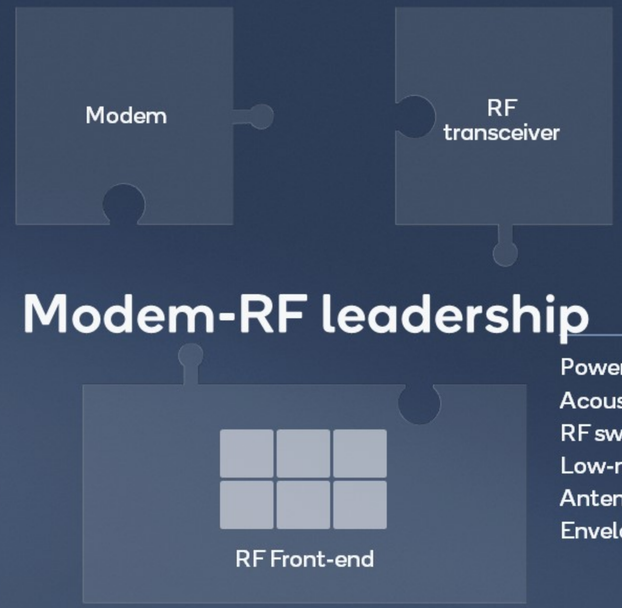
4th gen mmWave modules

2nd gen Qualcomm® Smart Transmit™ system for higher throughput

1. 3GPP specifications
2. GSA, October 2021
3. Internal data

Qualcomm Smart Transmit is a product of Qualcomm Technologies, Inc. and/or its subsidiaries

Best-in-class components



Power amps
Acoustic filters
RF switches
Low-noise amplifiers
Antenna Tuner
Envelope tracker

Unmatched co-design and system-level integration

- Real world throughput average speed, consistency
- Thermal performance
- Form factor
- Power consumption
- Coverage
- Time to launch

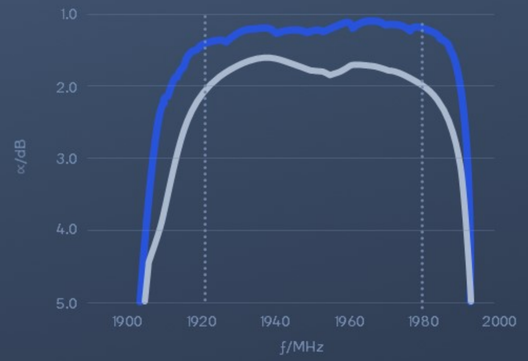
Industry-leading filter portfolio

Qualcomm Technologies
Closest competitor

2020
Strong traction

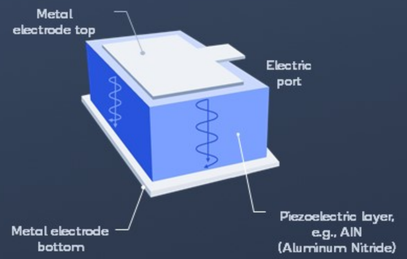
Qualcomm® ultraSAW Filter Technologies

5G low-band transmit

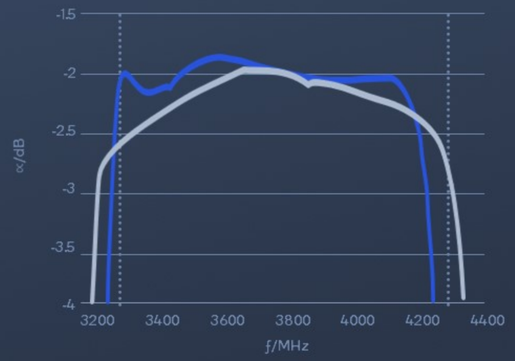


2021
High performance for higher bands

Qualcomm® ultraBAW Filter Technologies



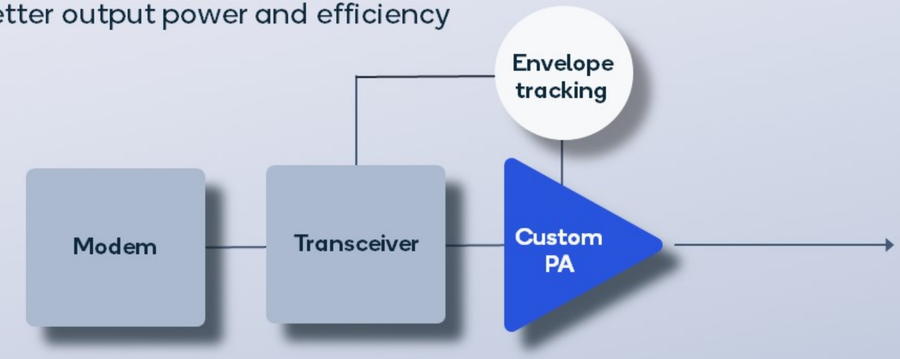
5G mid-band passband

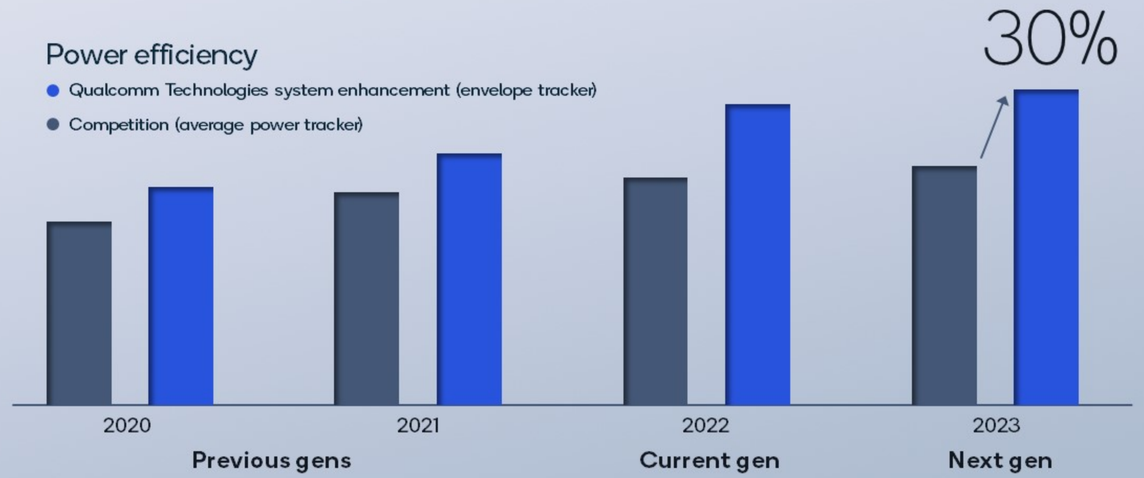


Source: Internal testing. Qualcomm ultraSAW and Qualcomm ultraBAW are products of Qualcomm Technologies, Inc. and/or its subsidiaries

Leading power amplifier design for superior modem-to-antenna performance

Custom InGaP HBT transistor
for better output power and efficiency

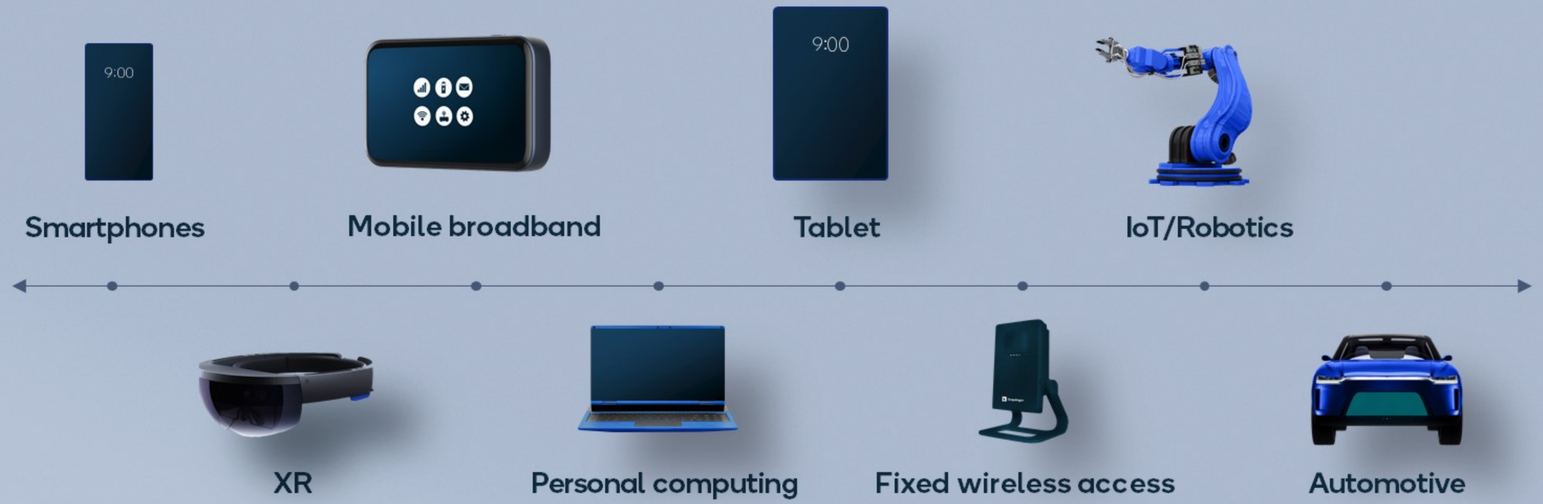




Source: Internal testing. Lab measurements in band n77 comparing modem-RF current consumption in a system based on Qualcomm Technologies' Envelope Tracking against a system using competitor's average power tracking technology

Snapdragon
Modem-RF system

From R&D to multi-tier modem-RF roadmap, enhanced with AI



One
technology roadmap for the connected intelligent edge

Edge AI

Camera

Graphics

Processing

Connectivity

The
technology roadmap for the connected intelligent edge

Industry-leading patent portfolio

WORLDWIDE ACTIVE PORTFOLIO

100+ Countries and regions with patents issued

140K+ Granted patents/ pending applications

Fundamental 4G and 5G cellular innovation

- System-level design
- Waveform, modulation, coding, mobility
- Mobile mmWave
- Cellular tech and new verticals

Broad strength across enabling and related innovation

- RF and antenna
- Location
- AI and machine learning
- Multimedia
- Camera and imaging
- Wi-Fi and local connectivity
- Power management
- Processing platforms
- Software and security

Source: Internal data

Qualcomm Technology Licensing

150+ 5G license agreements

16B+ Licensed devices shipped

200M+ Licensed connected vehicle units shipped

Thank you

Qualcomm

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Actual results may differ materially from those referred to in the forward-looking statements due to a number of important factors, including but not limited to: the impact of the COVID-19 pandemic, and government policies and other measures designed to limit its spread; our dependence on a small number of customers and licensees, and particularly from their sale of premium-tier devices; our customers vertically integrating; a significant portion of our business being concentrated in China, which is exacerbated by U.S./China trade and national security tensions; our ability to extend our technologies and products into new and expanded product areas, and industries and applications beyond mobile handsets; our strategic acquisitions, transactions and investments, and our ability to consummate strategic acquisitions; our dependence on a limited number of third-party suppliers; risks associated with the operation and control of our manufacturing facilities; security breaches of our information technology systems, or other misappropriation of our technology, intellectual property or other proprietary or confidential information; our ability to attract and retain qualified employees, and to successfully operate under a hybrid working environment; the continued and future success of our licensing programs, which requires us to continue to evolve our patent portfolio and to renew or renegotiate license agreements that are expiring; efforts by some OEMs to avoid paying fair and reasonable royalties for the use of our intellectual property, and other attacks on our licensing business model; potential changes in our patent licensing practices, whether due to governmental investigations, legal challenges or otherwise; adverse rulings in governmental investigations or proceedings; our customers' and licensees' sales of products and services based on CDMA, OFDMA and other communications technologies, including 5G, and our customers' demand for our products based on these technologies; competition in an environment of rapid technological change, and our ability to adapt to such change and compete effectively; failures in our products or in the products of our customers or licensees, including those resulting from security vulnerabilities, defects or errors; difficulties in enforcing and protecting our intellectual property rights; claims by third parties that we infringe their intellectual property; our use of open source software; the cyclical nature of the semiconductor industry, declines in global, regional or local economic conditions, or our stock price and earnings volatility; our ability to comply with laws, regulations, policies and standards; our indebtedness; and potential tax liabilities. These and other risks are set forth in our Annual Report on Form 10-K for the fiscal year ended September 26, 2021 filed with the SEC. Our reports filed with the SEC are available on our website at www.qualcomm.com. We undertake no obligation to update, or continue to provide information with respect to, any forward-looking statement or risk factor, whether as a result of new information, future events or otherwise.

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