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DEVCON

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MIPI –
Making the **5G** Vision a Reality



MIPI Mobile Interfaces:
**WIRING THE
FUTURE OF 5G**

MIPI ALLIANCE
DEVELOPERS
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19 OCTOBER 2018
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[MIPI.ORG/DEVCON](https://mipi.org/devcon)

Agenda

<p>The Vision What is 5G?</p>	<p>Kevin Yee</p>
<p>The Future Where is 5G going?</p>	<p>Kevin Yee</p>
<p>The Reality MIPI 5G Readiness</p>	<p>Kenneth Ma</p>
<p>The Plan MIPI 5G – A MIPI Strategic Priority</p>	<p>Kenneth Ma</p>



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The Vision: What is 5G all about?



Kevin Yee, MSG Chair
Cadence Design Systems

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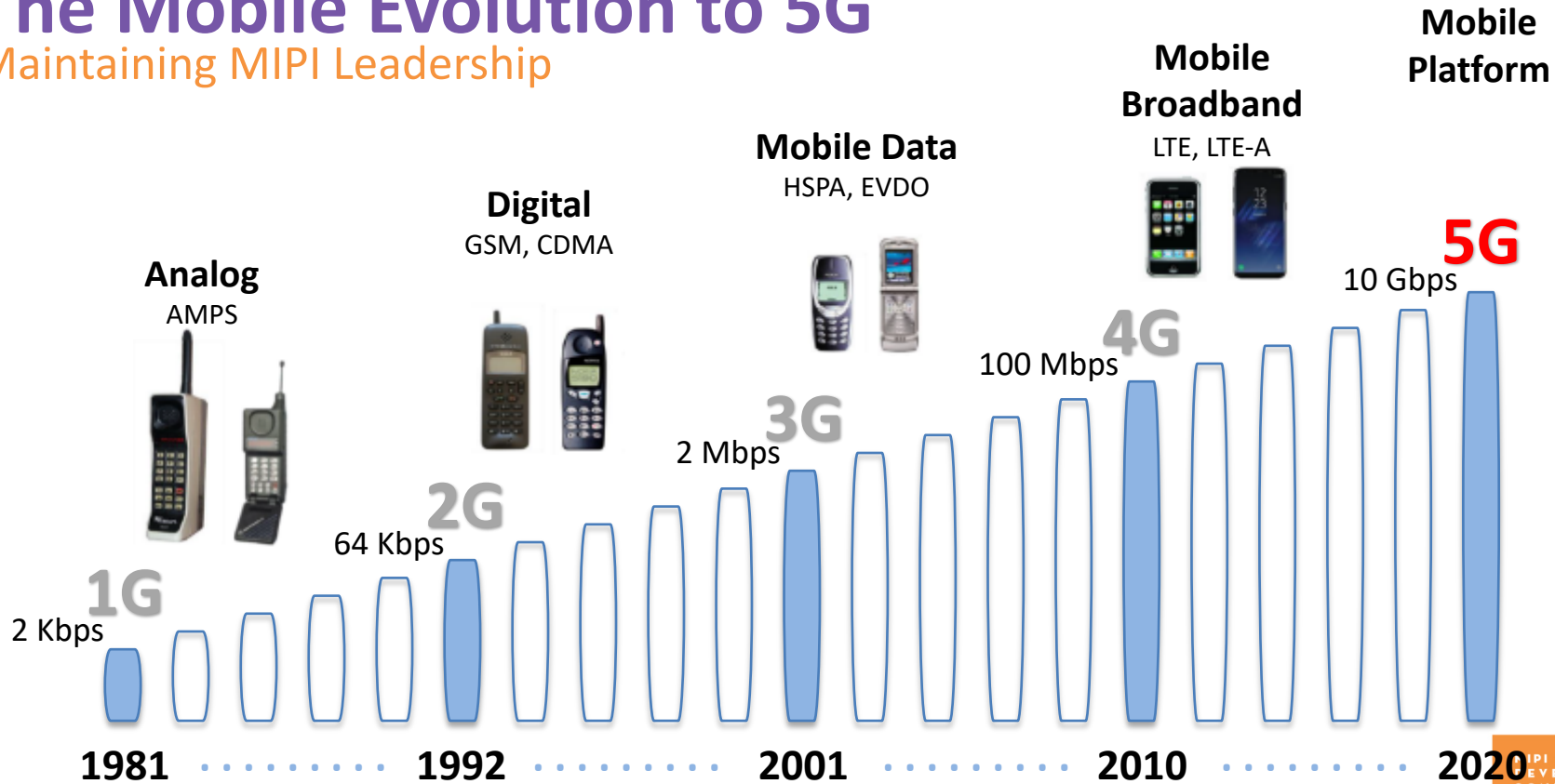
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What is the 5G Vision?

Connecting Everyone
...to Everything
...all the time

The Mobile Evolution to 5G

Maintaining MIPI Leadership



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5G in the market!

- All about 5G - Mobile World Congress 2018!
 - 5G has moved from concept to implementation
 - 5G infrastructure build up is happening NOW!
 - 5G commercial deployment by End 2018 !
 - 5G concept Smartphones NOW!
- 5G starts with Smartphones & Mobile Hotspots
 - Up to 20x faster than LTE and broadband
 - 5G smartphones announced - deployment late '18 to 1H'19
- 5G mobile and MIPI
 - Cameras, Display, Audio, RFFESM, Sensors, UniPro[®]/UFS
 - 5G mobile continues to leverage MIPI specifications

Carrier	Initial Number of 5G Markets	Sample Cities	Timeline
AT&T	12	Atlanta, Dallas, Waco	Launching mobile hotspot by end of 2018
Sprint	6	Atlanta, Chicago, Dallas, Los Angeles	First half of 2019
T-Mobile	30	Dallas, Las Vegas, New York, Los Angeles	Laying down equipment throughout 2018
Verizon	5	Sacramento	Fixed wireless coming later this year



MIPI – Still leading in 5G Mobile!

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5G will be **BIG** ... by the numbers!

\$275B

New investments

20x

Faster than 4G

13%

5G mobile adoption by 2021 (US)

10 Gbps

Throughput/Performance

\$500B

In economic growth

3M

New jobs

- Auto.
- Telemetry
- Infotainment
- More...V

74%

Responded: eMBB highest priority

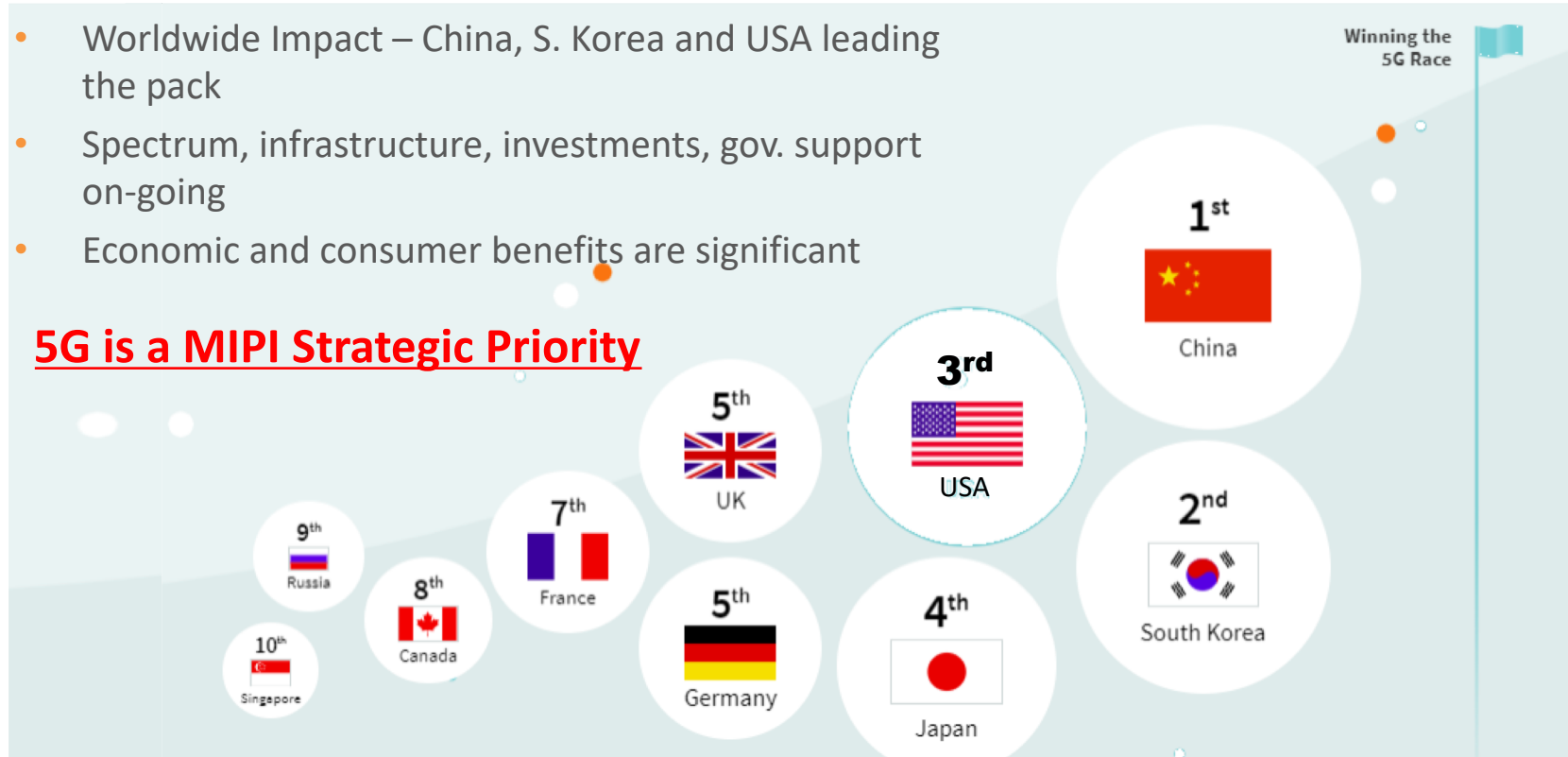
1.1B

5G Connections by 2025

5G – The Race is on...

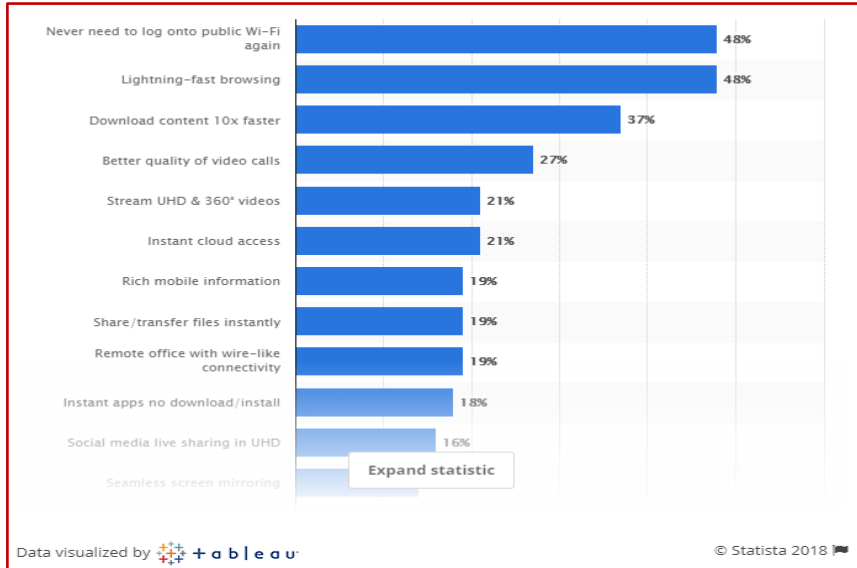
- Worldwide Impact – China, S. Korea and USA leading the pack
- Spectrum, infrastructure, investments, gov. support on-going
- Economic and consumer benefits are significant

5G is a MIPI Strategic Priority



Why 5G...a Changing World?

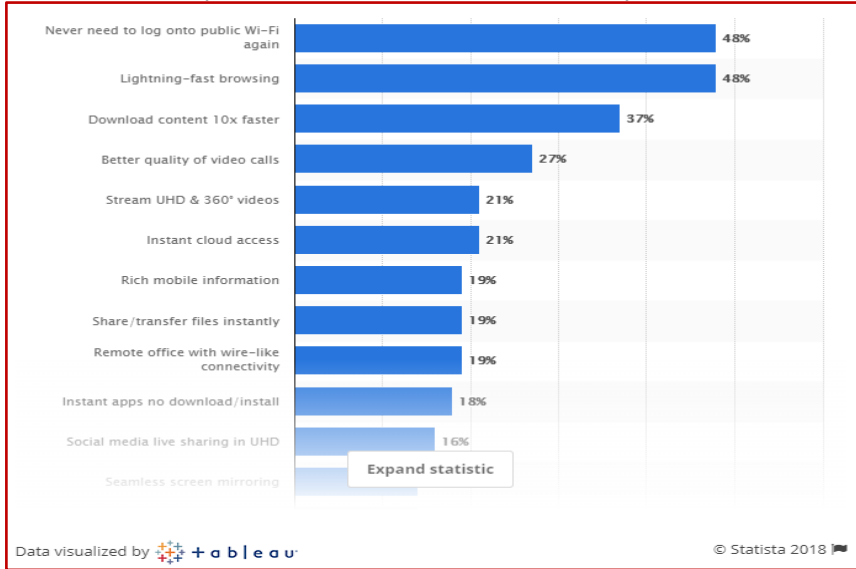
Top 5G eMBB Use Cases in 2019 & Beyond



- A Better Wireless Experience
- Always Connected
- Much Much Faster
- Higher Quality
- More Data
- Access All the Time

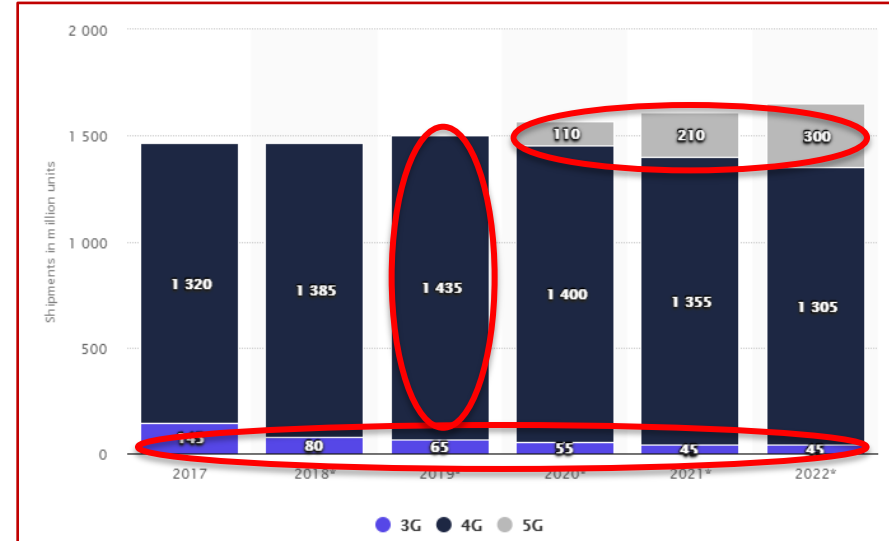
The Transition to 5G Mobile

Top 5G eMBB Use Cases in 2019 & Beyond



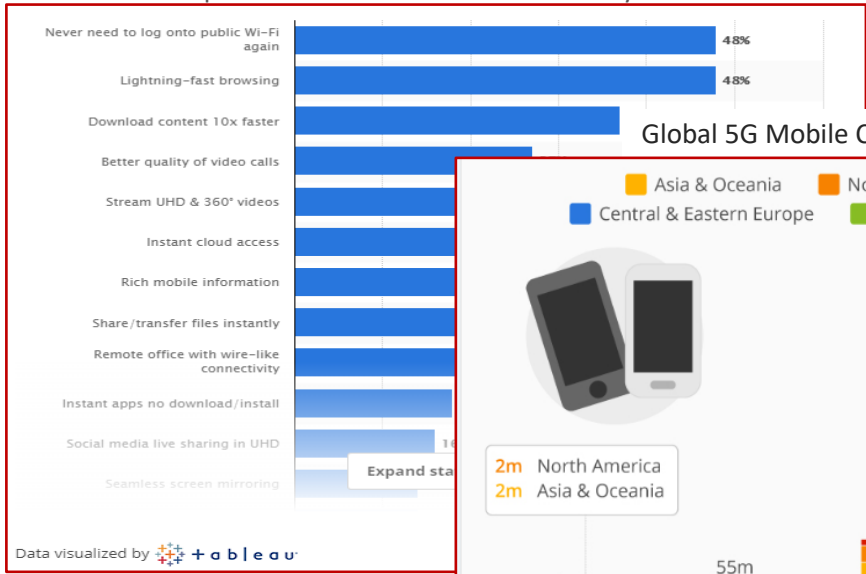
- 3G – Diminishing
- 4G – Peaking in 2019
- 5G - Ramping

Worldwide Smartphone Shipments



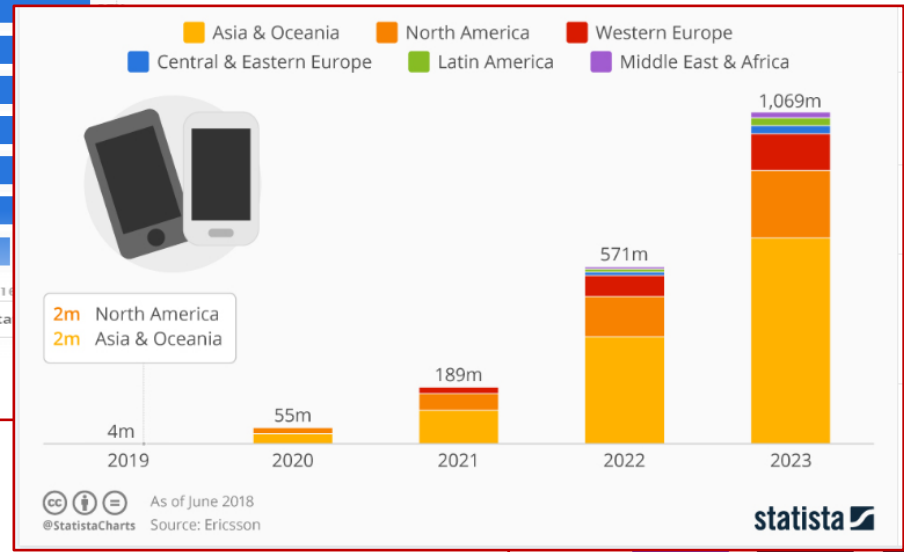
The 5G Mobile Adoption

Top 5G eMBB Use Cases in 2019 & Beyond

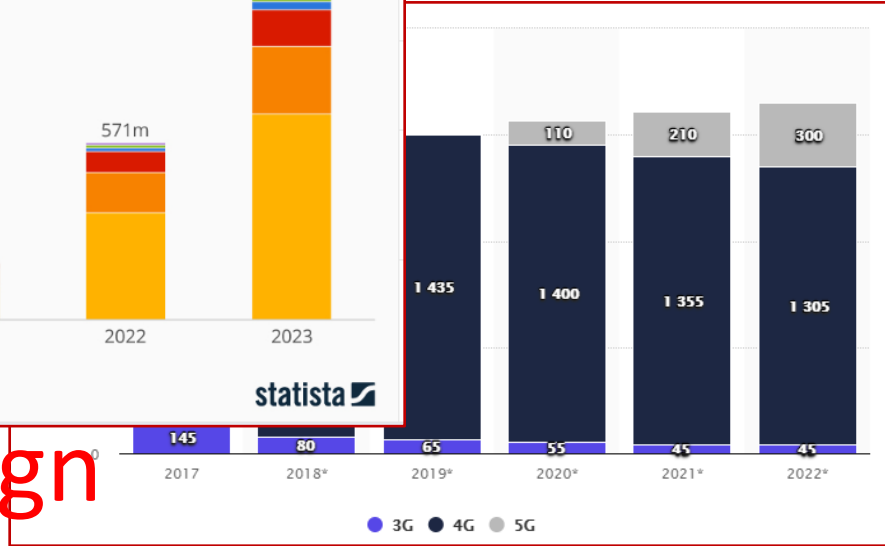


5G is here...

Global 5G Mobile Connections Forecast



Smartphone Shipments



...Start Your MIPI Design



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The Future: Where is 5G Going?



Kevin Yee, MSG Chair
Cadence Design Systems

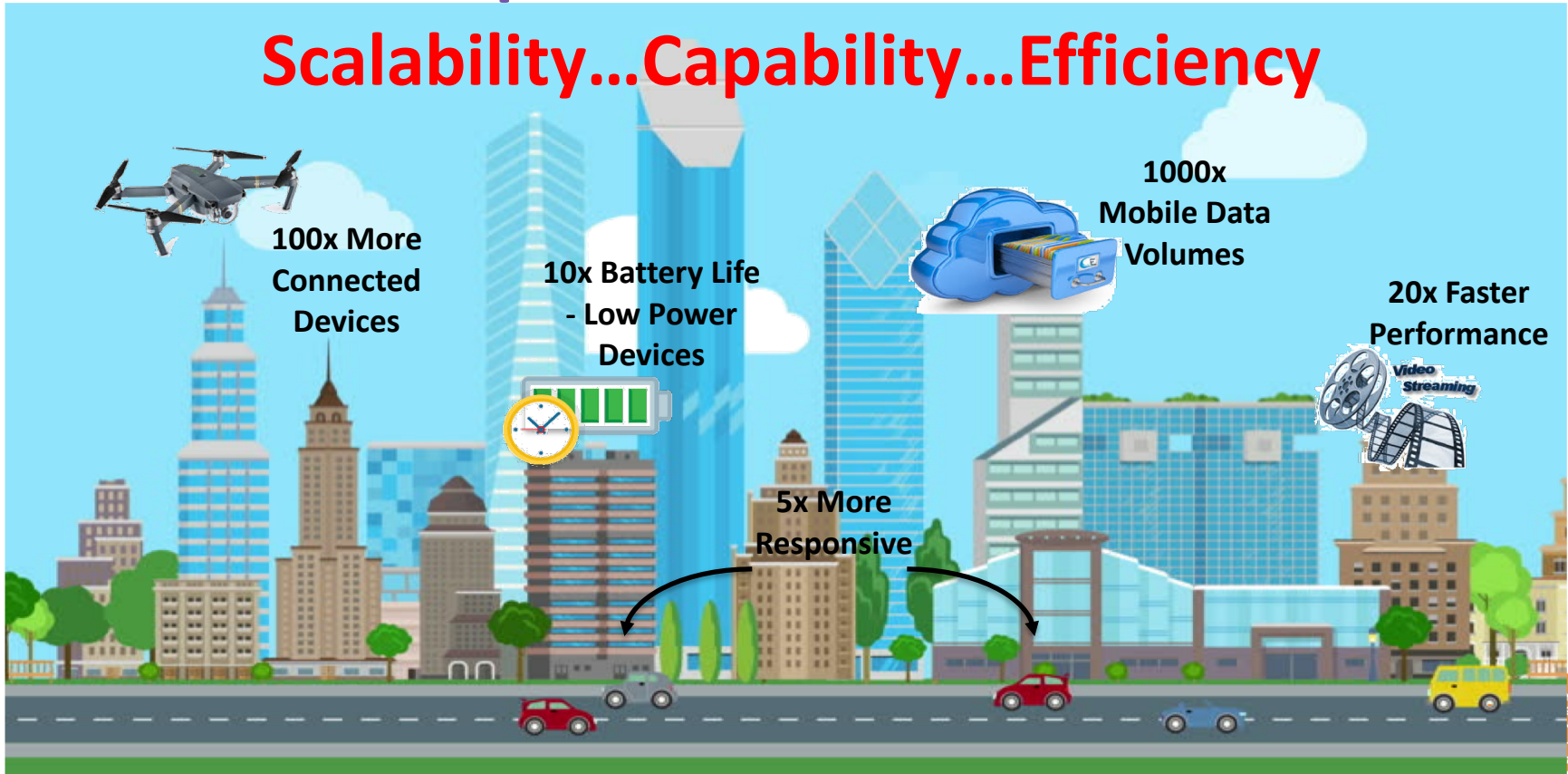
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5G – What to expect?

Scalability...Capability...Efficiency



5G: Changing the way we live

Health Care

Remote doctors to diagnose, treat and monitor patients real-time; remote operations



Entertainment & Commerce

Streaming & interactive media;
Banking;
AR/VR/XR;



Smart Cars

The ultimate mobile phone, autonomous driving, v2v, v2infrastructure



Smart City/Homes/Schools

Updates to appliances in the home or communications directly to city traffic



5G Still in its infancy...anything can happen



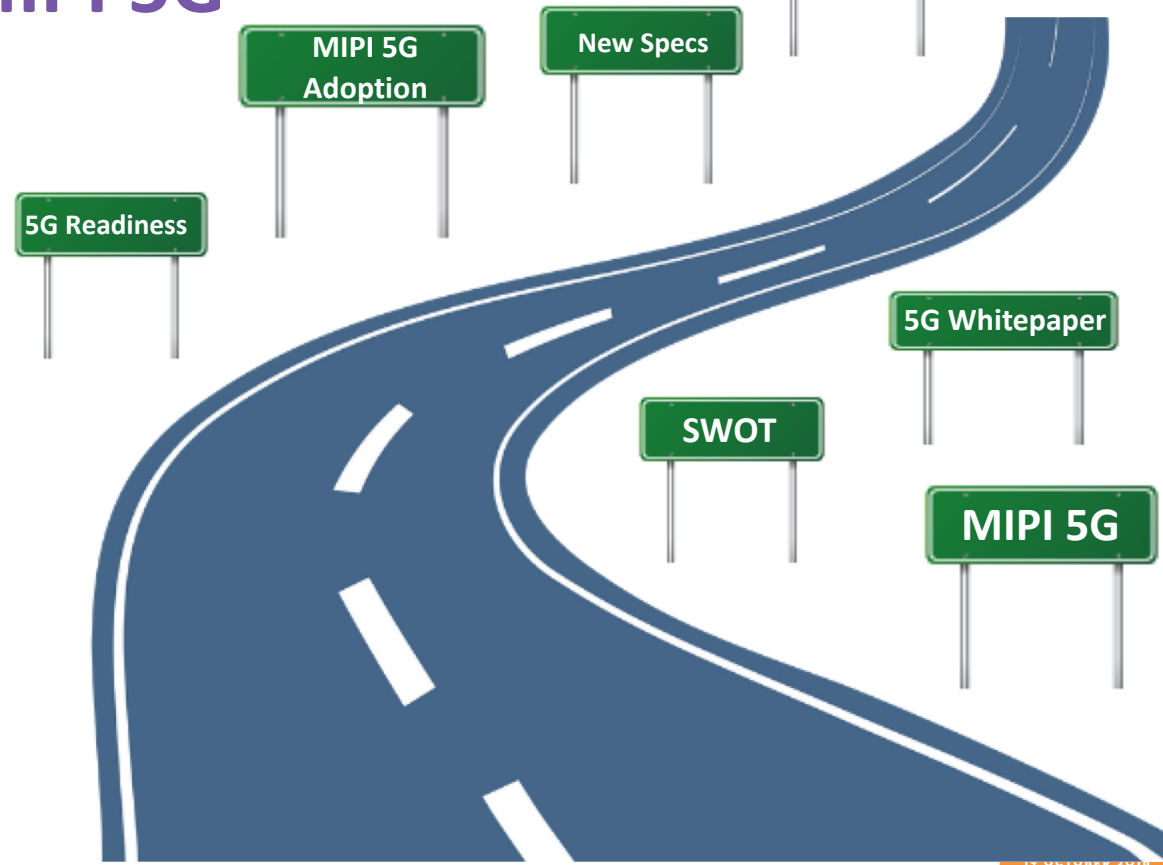
MIPI Mobile Interfaces:
**WIRING THE
FUTURE OF 5G**

- 5G to enable new Emerging use cases
 - Higher Speed, Connectivity, Reliability, Mobility and Lower Latency
 - Will TOUCH every aspect of our lives!
- Inflection Points to many vertical markets
 - 5G Broadband replacing Fixed Broadband?
 - 5G Smartphone becomes Home Media hub?
 - Multi-Party HD Telepresence Anywhere replaces fixed telepresence systems?
- Where can MIPI add value...**Opportunities?**

<p>Broadband access in dense areas</p> <p>PERVASIVE VIDEO</p>	<p>Broadband access everywhere</p> <p>50+ MBPS EVERYWHERE</p>	<p>Fixed Broadband Replacement</p> <p>5G BROADBAND TO HOME</p>	<p>Broadcast-like services</p> <p>BROADCAST SERVICES</p>	<p>Higher user mobility</p> <p>HIGH SPEED TRAIN</p>	<p>Massive Internet of Things</p> <p>SENSOR NETWORKS</p>
<p>Extreme real-time communications</p> <p>TACTILE INTERNET</p>	<p>Lifeline communications</p> <p>NATURAL DISASTER</p>	<p>Ultra-reliable communications</p> <p>E-HEALTH SERVICES</p>	<p>V2X, Autonomous Driving</p> <p>DENSE, RELIABLE LOW LATENCY</p>	<p>AR/VR, Online Gaming</p> <p>10X LOWER LATENCY</p>	<p>Smart City Automation</p> <p>EFFICIENCIES</p>

What's Next for MIPI 5G

- MIPI Mobile Interfaces: Wiring the Future of 5G
- Maintain Leadership in the Mobile Market
- Expand Leadership Beyond Mobile where it makes sense
- Enable our Members and the Industry to be successful in the 5G-era





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The Reality: Is MIPI 5G Ready?

Kenneth Ma, TSG Chair
Huawei/HiSilicon



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Potential Implications of 5G to MIPI Specs

- What changes to MIPI specifications because of 5G?
 - 5G is not just mobile. Broader Application use cases.
 - 5G NR : Key RF Technology innovations
 - Changing requirements: Performance, Reach, Power, etc.
- Examples of potential impacts / implications:
 - MIPI RFFE – Massive MIMO, mmWave
 - MIPI CSI-2SM – Movement from Camera to Vision and Imaging in emerging use cases
 - MIPI DSI-2SM – Increase in Display resolution, reach, expansion to Touch and XR use cases
 - MIPI I3CSM – More and more highly accurate sensors

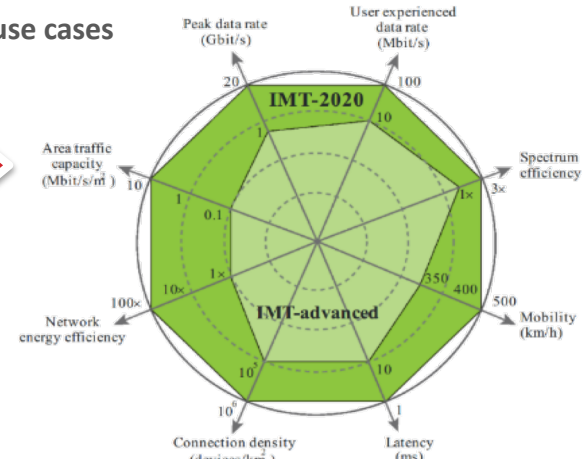


- Higher Throughput
- Lower Latency
- Reliability
- Mobility
- Range
- Device Density

- eMBB
- MCC / Mission Critical Communications
- mMTC / Massive Scale Connectivity (IoT, Sensors, Wearable)

- 4K/8K streaming
- Online Gaming
- Instant Cloud
- 360° video up/down
- AR/VR/XR
- Autonomous Driving
- V2X comm
- Tactile Internet
- Health Monitors
- Many others....

- 5G Mobile devices
- XR HMD
- Connected Car/Drone
- Multi-Sensor devices
- Wearables
- Health Monitors
- IoT
- Many others....



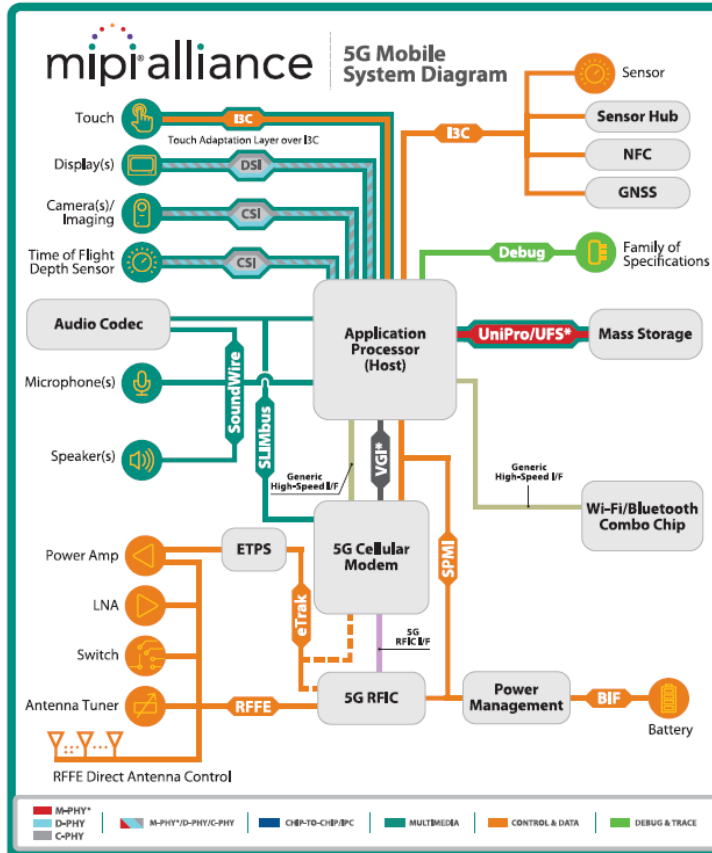
MIPI 5G Mobile Block Diagram

A Practical Look

5G

MIPI Mobile Interfaces:

WIRING THE FUTURE OF 5G



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MIPI RFFE is **Ready** for 5G-Mobile

- **MIPI RFFE v2.1 supports 5G NR radio FR1 (sub-6 GHz) bands and introduced additional features:**
 - Lower Latency.
 - Multiple message types; Master-to-Master Commands. New Masked write command supports RMW.
 - Flexible bus configuration; Extended Trigger support.
 - Longer reach (or trace lengths) support to accommodate the needs for some applications.
- **Status:**
 - MIPI RFFE v2.1 is poised to be deployed in 1st wave of 5G-enabled Smartphones coming in 2019
 - MIPI RFFE v2.1 is 5G-Ready
- **Upcoming 5G NR Phase 2:**
 - v2.1 has potential gaps with 5G NR Phase 2: mmWave, Massive MIMO up to 16 Tx/Rx antenna elements
 - WG evaluating MIPI RFFE v3.0 and MIPI RFFE-NG to meet:
 - 5G NR FR2 (24.25 GHz to 56 GHz) bands and Phase 2 requirements; Massive MIMO, Advanced Carrier Aggregation
 - Higher Data Throughput, more Tx/Rx path and further; e.g., Multi-lane, Enhanced Protocol, Faster Bus-Frequency
 - Latency Reduction: Shorter Configuration (target $\leq 1\mu\text{s}$)
 - Protocol Enhancement, Event-Synchronization with Timed Triggers and Complex Trigger Support
 - RFFE WG working with IWPC to collect operators insights

MIPI RFFE SWOT: “Signaling” Changes to Come

Strength (S)

- 100% market adoption in 4G/LTE generation
- 5G-Ready: MIPI RFFE v2.x is poised to deploy in 1st wave of 5G Smartphones
- MIPI RFFE v2.1 enables lower latency, longer reach, additional Master to Master Command Sequences, and more configurations with Extended Trigger support
- Easy to adopt new features as RFFE has maintained backwards compatibility, and continues to strive to keep backwards compatibility intact.

Weakness (W)

- None known at present – MIPI RFFE has striven to keep up with the addition of various features that have been identified to date – however, there are challenges to identify what else will be needed (before it is needed)
- For MIPI RFFE v3 and MIPI RFFE-NG inputs are being sought (incl. from IWPC survey of operators) to assist the RFFE WG in identifying gaps/needs for future 5G feature deployments

Opportunities (O)

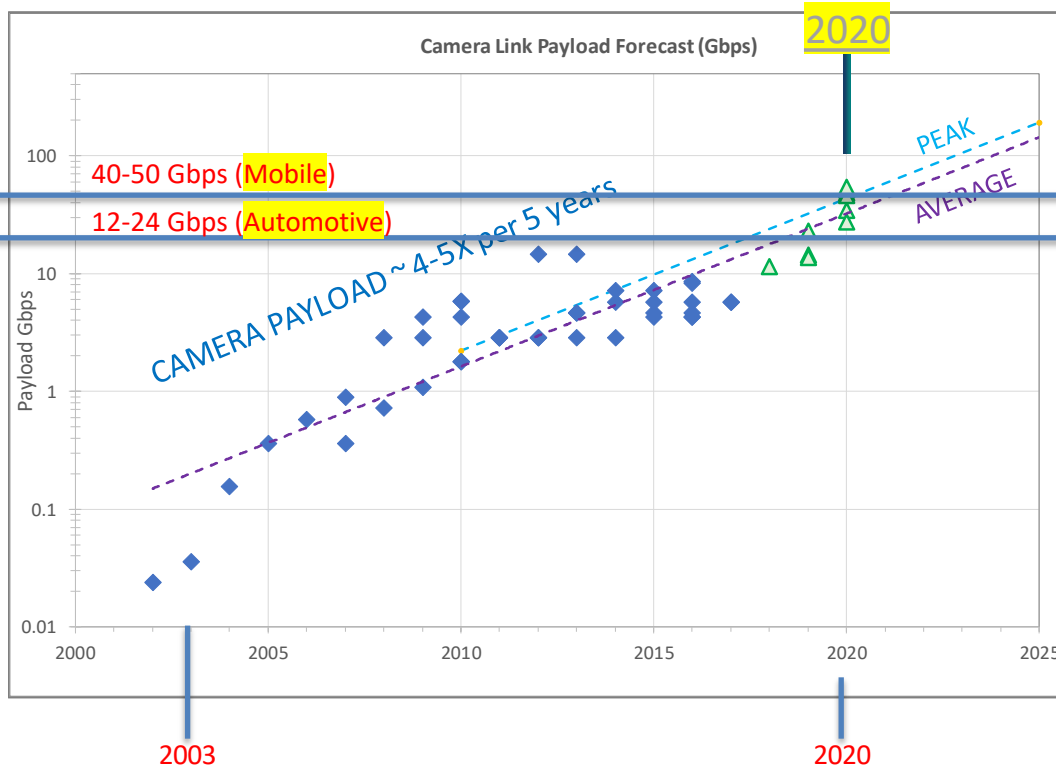
- RFFE v3.0, RFFE-NG to address 5G-Mobile Phase 2:
 - Higher Throughput, e.g., Multi-lane, Enhanced protocol, higher bus frequency
 - Latency Reduction: Protocol Enhancement, Event-Synchronization with Timed Triggers
 - Massive MIMO, Advanced Carrier Aggregation
 - Complex Trigger Support

Threat (T)

- It is believed by many that RFFE currently has the features most needed for initial 5G deployments
- Work has started on MIPI RFFE v3 and also on MIPI RFFE-NG to address emerging/evolving needs for 5G, particularly for later deployments
- However – if some alternate competition were to emerge that rallied the kind of support that RFFE currently has, that could be a competitive threat
- Fails to add features or fails to add features in a timely manner

MIPI CSI-2SM: Designed to Handle 5G and Beyond...

Mobile Camera to Vision/Imaging & Automotive



Mobile targets:

MIPI CSI-2 v3.0 (Target 4Q 2018)

- 40 Gbps, MIPI Standard channel
- 50 Gbps, MIPI Short channel

Automotive targets (End'19):

- 12-24 Gbps
- Over 15m (auto)

New Features:

- SmartROI for IoT, drone and other real-time applications
- AVRET (AR/VR/MR eye tracking)
- LRTE to reduce conduit latency
- ALPS to improve native support for long reach
- RAW 16/20/24 for superior IQ
- Enhanced MIPI CCISM support – I3C SDR/HDR modes
- MIPI CCSSM enables unified driver development
- Security features beyond interleaved encryption

MIPI Camera WG SWOT: “Seeing” your Way to the Future

Strength (S)

- 5G ready: camera I/F of choice for 4G/5G mobiles
- MIPI CSI-2SM supports BW & resolutions beyond 2021 needs
- Multi-cameras, depth/ToF sensors, face detection
- De-facto choice in many AV/VR/MR and IoT devices, e.g. HMD, drones
- Deployed in automotive platforms
- Unified end-to-end imaging & vision conduit solution for near real-time processing and decision making

Weakness (W)

- Native support for longer reach (ETA: EOY 2018)
- Provisions for autonomous platform such as automobiles and drones (ETA: EOY 2019)

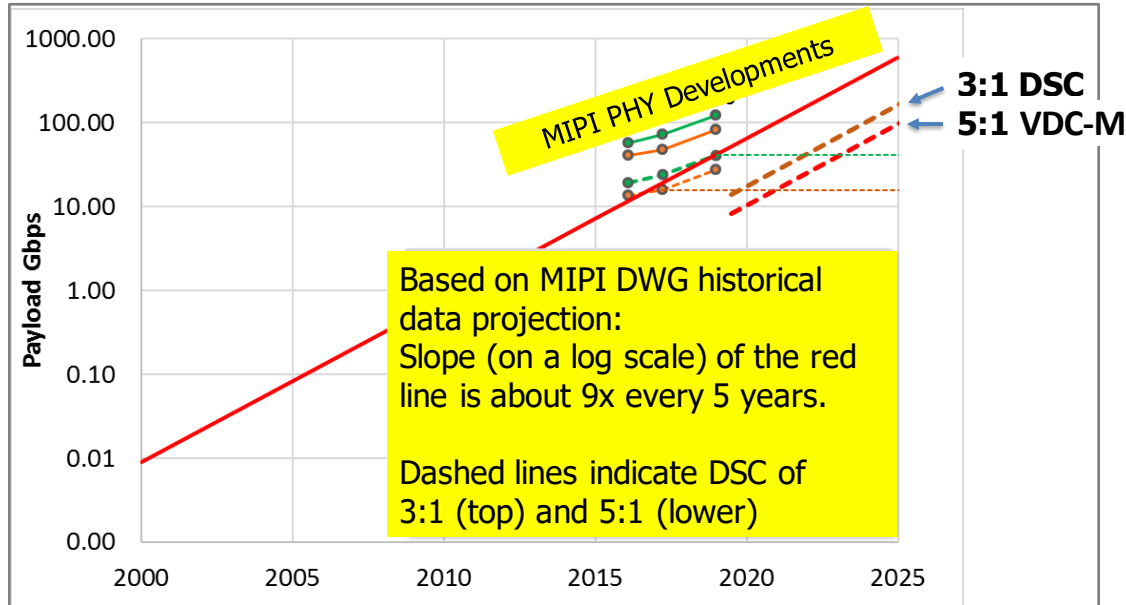
Opportunities (O)

- SmartROI for IoT, drone and other real-time applications
- AVRET (AR/VR/MR eye tracking)
- LRTE to reduce conduit latency
- ALPS to improve native support for long reach
- RAW 16/20/24 for superior IQ
- Enhanced CCISM support – MIPI I3C SDR/HDR modes
- MIPI CCSSM to enable unified driver development on APs
- Security features beyond interleaved encryption

Threat (T)

- USB Camera sensors

MIPI DSI-2SM Requirement Analysis



Mobile targets:

MIPI DSI-2 v1.1 (Current)

- Data Rate Without / 3:1 / 5:1 compression
 - D-PHY v2.1 up to 18 / 54 / 90Gbps (4 lanes)
 - C-PHY v1.2 up to 24 / 72 / 120Gbps (3 lanes)
- Meet 2024+ product cycle's peak bandwidth requirements.

With display stream compression, MIPI interfaces support the anticipated Display speeds of 100+ Gbps

MIPI Display WG SWOT: Your “View” to the Big Picture

Strength (S)

- 5G-Ready: Display I/F of Choices in all 4G/5G mobiles
- Support VESA DSC (8bpp) and VDC-m (6bpp) visually lossless streaming display compression
- With latest MIPI D-/C-PHYSM, MIPI DSISM & MIPI DSI-2SM supports BW & resolutions beyond 2021 needs (projected 2024+)
- Popular choices in AR/VR devices, e.g., HMD, can support Dual 4K+, High frame rate displays

Weakness (W)

- Currently Short-reach only

Opportunities (O)

- XR: Leverage Unique advantages that Camera, Display, Audio and Sensor WG are all under one roof of MIPI Alliance. Enhance Display-Camera sync and other sensory synchronization to alleviate “VR Sickness”

Threat (T)

- eDP is popular in some embedded and automotive applications.

MIPI is 5G-Ready!

MIPI WG	Mobile-5G Readiness	Readiness Details / Future Plans / 5G Enhancements
Audio WG	5G-Ready	<ul style="list-style-type: none"> - MIPI SLIMbus® v2.0 is poised to be deployed in 5G-enabled Smartphones in 2019 - MIPI SoundWire® 1.1/1.2 already exceeds state-of-the-art audio requirements. - Upcoming SoundWire spec plans to lower EMI and extends reach further.
Camera	5G-Ready	<ul style="list-style-type: none"> - BW/Resolution exceeds state-of-the-art beyond 2021 requirements. Multi-Camera, Depth Sensing, LRTE, USL, AVRET, SmartROI, GLD, RAW16/20/24, Enhanced CCI with I2C_FM+ and I3C.
Display	5G-Ready	<ul style="list-style-type: none"> - BW/Resolution exceeds state-of-the-art beyond 2021 requirements. - Exploring MIPI XR efforts which will be a key 5G use cases.
PHY	5G-Ready	<ul style="list-style-type: none"> - MIPI C/D/M-PHY® delivers BW beyond 2021 needs for Camera/Display/UniPro®
RFFE	5G-Ready	<ul style="list-style-type: none"> - Post-RFFE v2.1 will evaluate requirements to enhance 5G NR subsystem
RIO	5G-Ready (in process of release)	<ul style="list-style-type: none"> - MIPI VGI v1.0 enables substantial pin savings for 5G mobile. - 3-wire VGI (up to 76.8Mbps F/D) suits interface of Low/Mid IoT 5G Modem
Sensor (I3C)	5G-Ready	<ul style="list-style-type: none"> - MIPI I3CSM v1.x poised to become dominant next gen control interface for 5G mobile. - Sensor WG evaluating 5G reliability and security requirements post-v1.1 I3C
UniPro (UFS)	5G-Ready	<ul style="list-style-type: none"> - MIPI UniPro-based UFS v2.x and v3.0 is the primary storage interface in high-end Smartphones and upcoming 5G mobile.

**Download and Review MIPI 5G Whitepaper
and related MIPI Specs !**

MIPI 5G Enablement Status

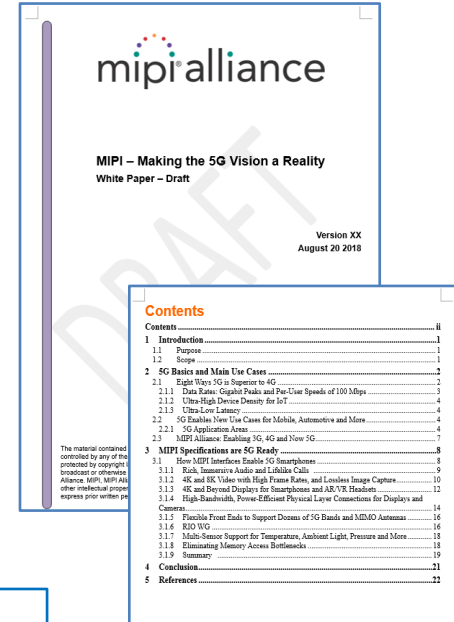
5G WG SWOT (Strength, Weakness, Opportunity, Threat) (Shown is CWG 5G SWOT example)

Strength (S) <ul style="list-style-type: none"> - 5G ready: camera I/F of choice for 4G/5G mobiles - CSI-2 supports BW & resolutions beyond 2021 needs - Multi-cameras, depth/ToF sensors, face detection - De-facto choice in many AV/VR/MR and IoT devices, e.g. HMD, drones - Deployed in automotive platforms - Unified end-to-end imaging & vision conduit solution for near real-time processing and decision making 	Weakness (W) <ul style="list-style-type: none"> - Native support for longer reach (ETA: EOY 2018) - Provisions for autonomous platforms such as automobiles and drones (ETA: EOY 2019)
Opportunities (O) <ul style="list-style-type: none"> - SmartROI for IoT, drone and other real-time applications - AVRET (AR/VR/MR eye tracking) - LRTE to reduce conduit latency - ALPS to improve native support for long reach - RAW 16/20/24 for superior IQ - Enhanced CCI support—IBC SDR/HDR modes - CCS to enable unified driver development on Aps - Security features beyond interleaved encryption 	Threat (T) <ul style="list-style-type: none"> - USB Camera sensors

Marketing Rollout Plan

- 5G Mobile white paper
- 5G Tagline contest
- One-page summary PDF fact sheet
- Presentations
- Webinars
- News Letter
- Contributed articles
- 5G System Diagrams
- 5G Website update
- Press Releases
- DevCon

MIPI 5G Whitepaper



Integrate with SRP and WG Planning Process

Description of Proposed Changes					
Key features 1-2 have not changed, items 3-5 are new requests from CWG/market applications. A separate SRP for CSI-2 v4.0 will be submitted.					
Target is to Evolve CSI-2 Imaging Subsystem for Mobile and Mobile influenced platforms					
Key Features/ Functions/Requirement	Optional O: Mandatory	Benefits/Value/Pros	Weaknesses/Cons	Alternatives to Proposed Feature	Applications/ Industry Segments
		i.e., What does new feature help solve?	i.e., What negative(s) does this new feature raise? [1]	i.e., are there alternatives to this feature? [2]	e.g., Mobile, IOT, Automotive, 5G, Security, other...

- **Issues & Risks to highlight to MIPI TSG/Board**
 - No items to raise to TSG/Board
- **WG Timeline/schedule and/or SRP/CTS/5G updates**
 - SRP: RFFE v3.0 SRP target for submission to TSG/MSG in Q3 2018. Planning pre-work on SRP during the Glasgow F2F.
 - 5G: Input to SWOT provided in May. Additional WG feedback may come after Jun-4 WG conference call (under WG review)
 - Timeline: No changes to WG timeline. AppNote/FAQ published on schedule. v3.0 schedule is TBD (for WG discussion at F2F).





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The Plan:

5G A MIPI Strategic Priority

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MIPI 2018-2019 Strategic Priorities



Technical Roadmap: 5G-Mobile Focus

- Drive next generation of mobile
 - Mobile evolving into 5G
- Assess MIPI's 5G readiness
 - Current MIPI specifications
- Identify, position and align
 - 5G requirements: current vs. future
 - Updates/new MIPI specifications
- Going beyond mobile
 - Alignment to our other strategic priority

Maintain MIPI's dominance in mobile and beyond

5G impacts our daily life and your Mobile devices

- In 4G/LTE era, its higher speed and better connections created substantial changes to our daily life, just a name a few below:
 - Mobile Video streaming → Storage, Display resolution, Battery life
 - Real-time Mobile Online Gaming → GPU perf, Lower latency, Battery life
 - Ubiquitous Mobile payment and Online finances → Security
 - Mobile ID → ID Authentication, Security
- In 5G era, visionaries predicted it will have unprecedented impact to our daily life and many vertical markets;
 - 5G Smartphones becomes Home Entertainment Hub → Entertainment behavior
 - More 360 video and XR experiences → Social and Gaming behavior
 - Mobile devices becomes Primary computing devices → Work behavior
 - Multi-Party HD Telepresence Anywhere replaces fixed systems → Business travel behavior

5G Mobile Platform Challenges



5G enables everything faster, higher speed, high BW
higher resolution/frame rate → Higher power consumption !



5G Device becomes primary productivity, social network and media hub.
Longer Use Time and Always On support requires Longer battery life !



Higher power, higher performance imposes more challenging
Power and Thermal management !



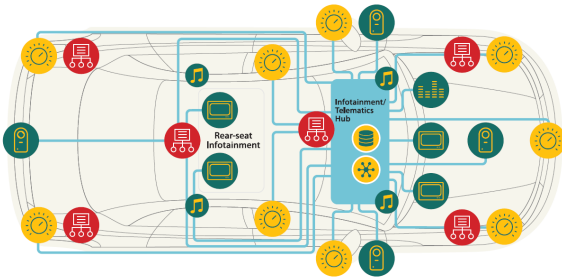
5G NR imposes more Complex RF design and EMI mitigations !



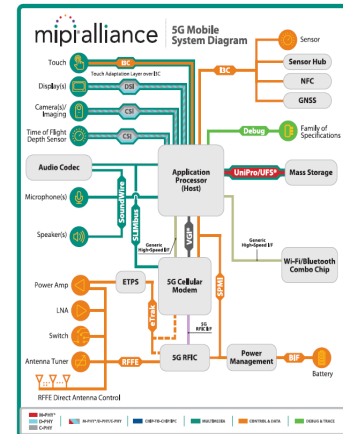
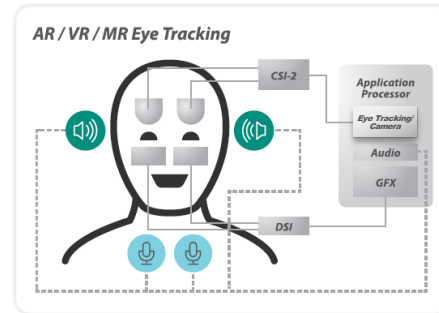
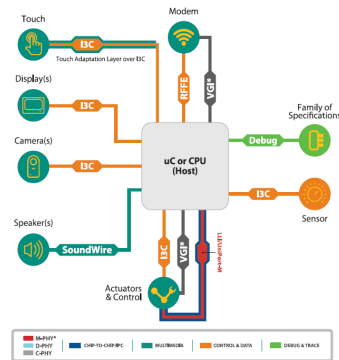
More of your daily “life” spent with the 5G mobile device. Platform Security and Reliability more critical than ever !

Emerging 5G Use Cases & MIPI “System Approach”

- Emerging use cases enabled by 5G (some are still unknown) can create opportunities and/or challenges to MIPI. Adopt “System Approach” to evaluate and address the evolving requirements in a holistic, end-to-end system-level manner.



mipiAlliance IoT System Diagram



MIPI Leadership in the 5G-Era

F.O.C.U.S.

- Focus on areas that play to MIPI's strengths:
 - Mobile 5G and then Mobile ++ (Beyond Mobile)
- Outreach to extend MIPI application spaces
 - To MIPI members and potential members
- Collaborate with leading organizations
 - Technical Liaisons
- Utilize our existing mobile specifications
 - Leverage and enhance specs to address 5G and beyond
- SWOT: Ensure 5G-readiness and beyond
 - Your help to drive MIPI specs forward!



<p>Strength (S)</p> <ul style="list-style-type: none"> - 5G ready camera I/F of choice for 4G/5G mobiles - CSI-2 supports BW & resolutions beyond 2021 needs - Multi-camera, depth/ToF sensors, face detection - De-facto choice in many AV/VR/MR and IoT devices, - Deployed in automotive platforms - Unified end-to-end imaging & vision conduit solution for near real-time processing and decision making 	<p>Weakness (W)</p> <ul style="list-style-type: none"> - Native support for longer reach (ETA: EOY 2018) - Provisions for autonomous platforms such as automobiles and drones (ETA: EOY 2019)
<p>Opportunities (O)</p> <ul style="list-style-type: none"> - SmartROI for IoT, drone and other real-time applications - AVRET (AR/VR/MR eye tracking) - LITE to reduce conduit latency - ALPS to improve native support for long reach - RAW 16/20/24 for superior IQ - Enhanced CSI support to IICSDM HDR modes - CCS to enable unified driver development on Apps - Security features beyond interleaved encryption 	<p>Threat (T)</p> <ul style="list-style-type: none"> - USB Camera sensors

Call To Action: Wiring the Future of 5G

- ***MIPI is Here and Ready for 5G***
 - Key Specifications are ready for deployment – Spread the Word
 - Bring your 5G thoughts into your WGs
- ***Beyond 5G Mobile***
 - Help identify 5G Mobile++ use cases (in MIPI Strategic Focus areas)
 - Help identify potential gaps and opportunities MIPI should address
 - Voice your needs and requirements in respective WGs

START YOUR 5G DESIGNS with MIPI !
MIPI Mobile Interfaces: Wiring the Future of 5G

mipi[®]
DEVCON

THANK
YOU

5G

MIPI Mobile Interfaces:
**WIRING THE
FUTURE OF 5G**

[MIPI.ORG/DEVCON](https://mipi.org/devcon)

ADDITIONAL RESOURCES

- MIPI 5G Whitepaper:
 - <https://mipi.org/mipi-specification-5G-readiness-assessment>
- MIPI Board Approved WG Specifications:
 - <https://mipi.org/specifications>