# VESA – DisplayPort™ Alternate Mode on USB-C®

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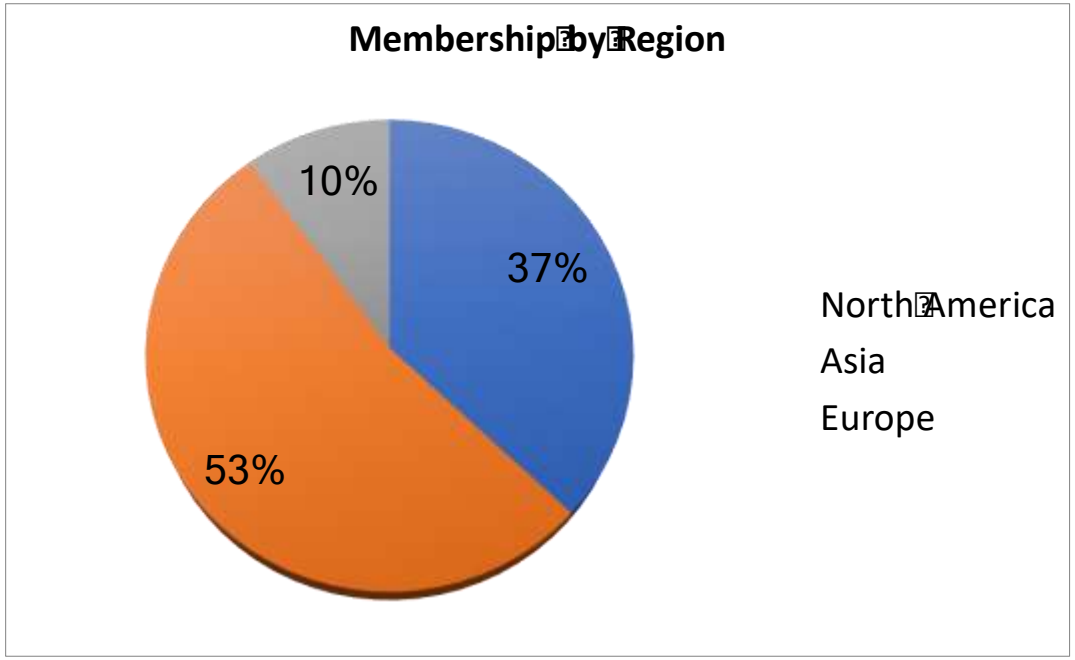
*USB Developer Days 2019 – Seattle, WA*

*September 18, 2019*

# Agenda

- **VESA Overview**
- DisplayPort Overview
- DisplayPort Alternate Mode on USB-C®
- Compliance Testing
- USB4™ DisplayPort™ Considerations
- Summary

# About VESA




- Global industry alliance with more than 290 member companies
- Leading PC/computer, display, hardware, software, and component manufacturers worldwide
- Mission to develop, promote and support ecosystem of vendors and certified interoperable products for the electronics industry
- Develops Open standards, contribution is open to all companies at all stages of development as well as promotion and marketing

# VESA Standards Enable Many Market Segments…

Monitors, PCs and laptops

Gaming consoles and headsets

Digital signage / kiosks

Smartphones and tablets

Automotive

Digital projectors

# …As Well as Many Aspects of Display Technology

**Display Interfaces**

- DisplayPort
- DisplayPort over USB-C (DisplayPort Alt Mode)
- Embedded DisplayPort

**High Dynamic Range**

- DisplayHDR

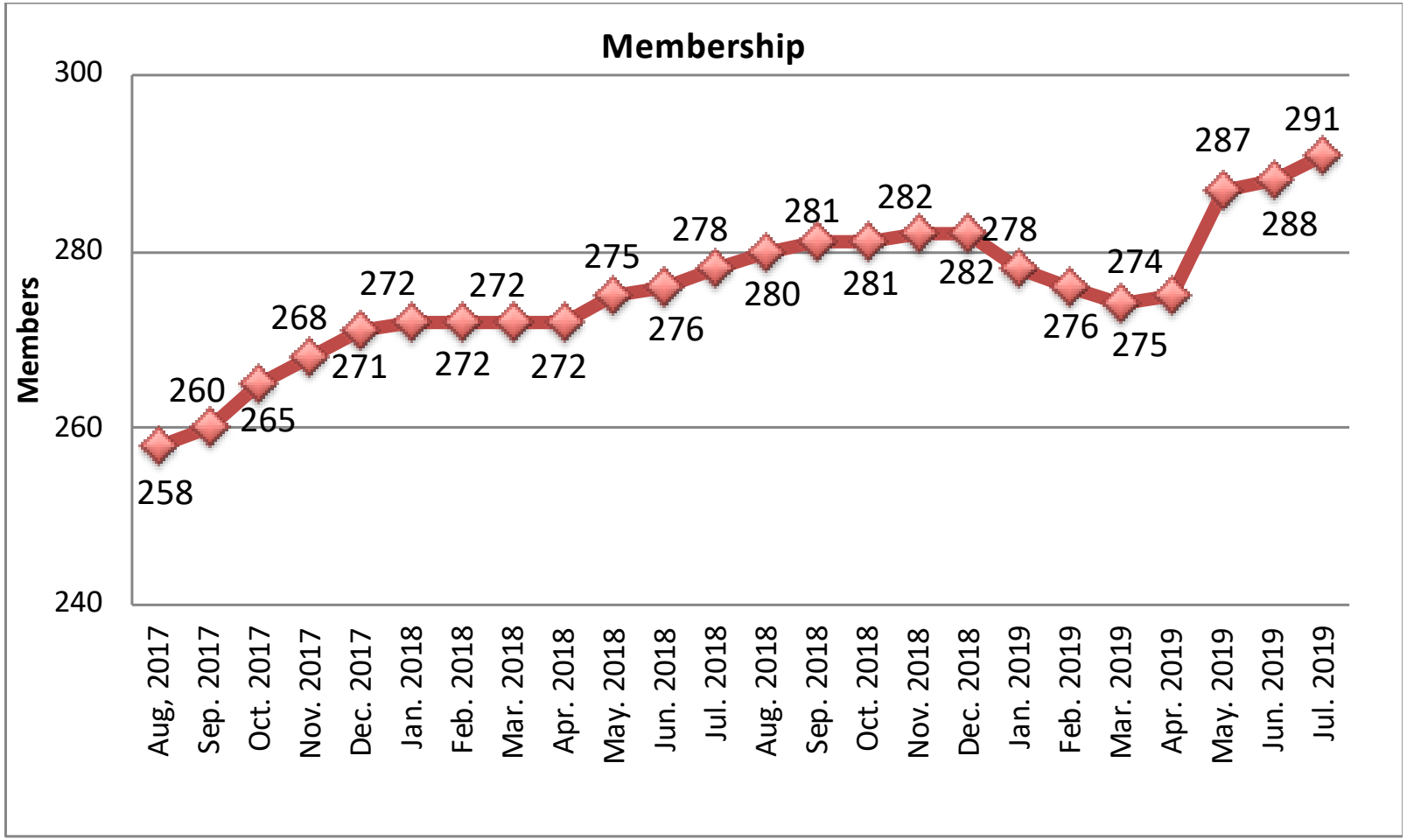
**Display Data Compression**

- Display Stream Compression (DSC)
- VESA Display Codec for Mobile (VDC-M)

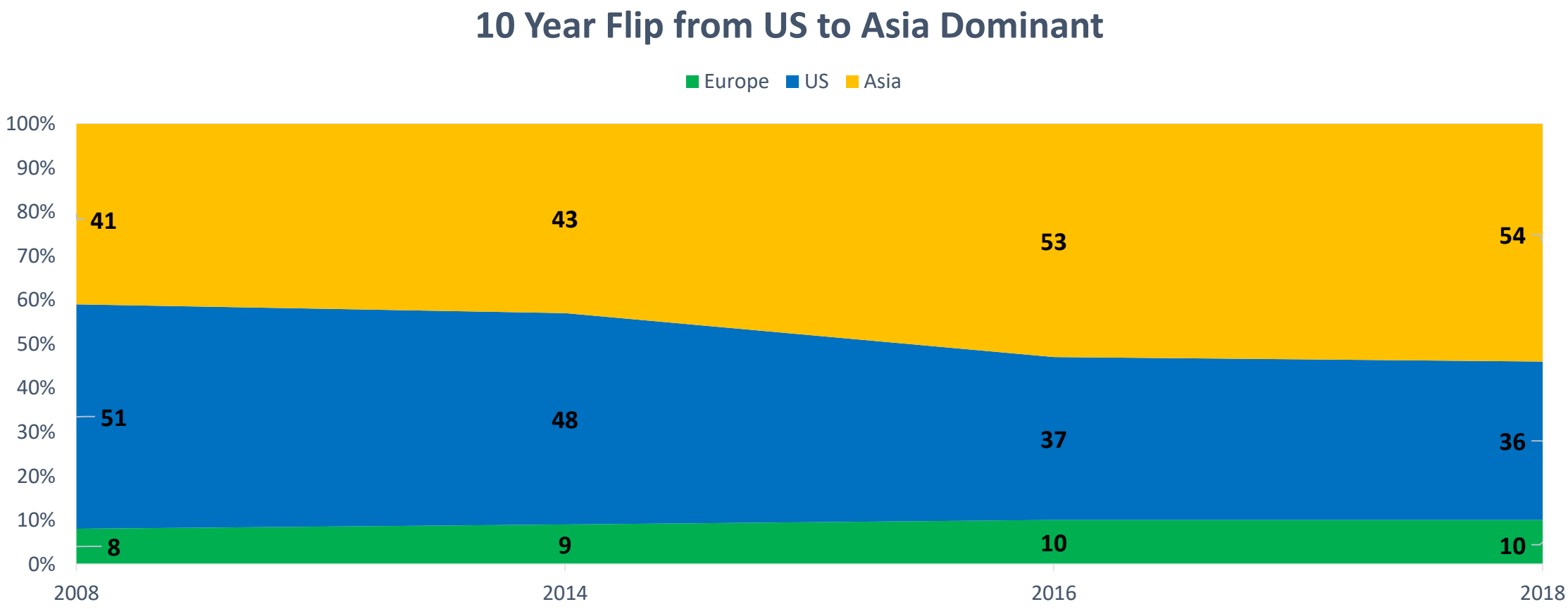
**Display Capability Parameters**

- DisplayID
- Extended Display Identification Data (EDID)
- Multi-Display Interface

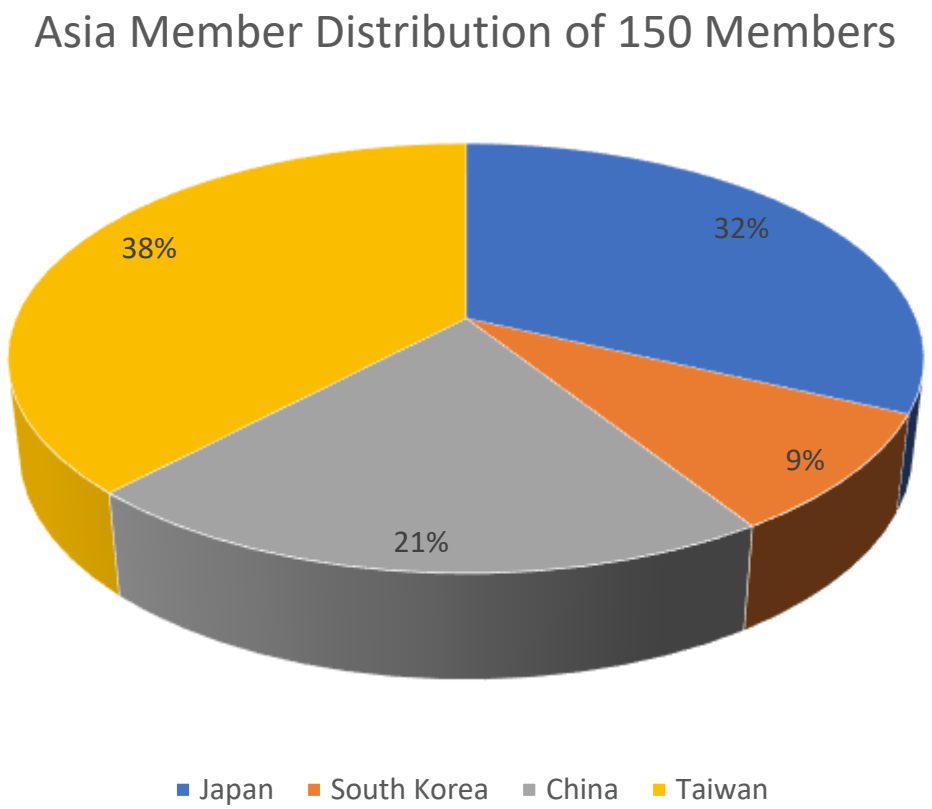
# VESA Membership Continues to Grow



# Historical Membership by Region



# VESA Asia Membership



# VESA Adds Local Asian Support Capability

- VESA has added local support to Asia region to address growing regional membership needs
- China (Mainland) and Taiwan are the fastest growing areas for VESA's membership.
- **Kellen** is VESA's Representative for all Chinese Speaking Areas of Asia
- This partnership will provide members with a communication option in their native language. Kellen will handle membership related activities including, new membership requests, renewals, PlugTest and event support and translation of VESA member messaging, etc.
- Members who wish to communicate in Chinese regarding VESA business may contact Maria Wang, Account Manager (AsiaVESA@kellencompany.com) or at +86 10 6580 0670. VESA is setting up a Wechat account for easy communication among members, and will keep members informed immediately once it is available.

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# DisplayPort™ Specification Summary

- The VESA DisplayPort Standard, Version 1.4, was released on March 1, 2016
  - Replaces DisplayPort Version 1.2a/DP1.3 for new designs
- Backward compatible, offers new optional features
  - HBR3 (8.1Gbps) capable products are shipping in volume
- DisplayPort 1.4 New Features
  - Forward Error Correction (FEC), Display Steam Compression (DSC)
  - Audio extensions, improved MST functionality, Adaptive Sync
  - 30 bit color; 8K 4:4:4, 7680X4320 @60Hz – Single Cable

# DP 1.4 Link Rate Increase

| DP Version Introduction | Link Rate Name | Bit rate | Max Resolution Support (24 bpp, 60Hz Refresh, 4:4:4 format) | Max Resolution Support (24 bpp, 60Hz Refresh, 4:2:0 format) |
|---|---|---|---|---|
| DP 1.0 | RBR | 1.62 Gbps | 1920x1080 | Not supported |
| | HBR | 2.7 Gbps | 2560x1600 | Not supported |
| DP 1.2 | HBR2 | 5.4 Gbps | 4K x 2K | Not supported |
| DP 1.3/1.4 | HBR3 | 8.1 Gbps | 5K x 3K | 8K x 4K |

Total useable data transfer rate for DP 1.4 = 25.92 Gbps

8.1 Gbps link rate, per lane
x 0.8 to account for 8b/10b transport coding overhead
x 4 maximum number of available lanes
25.92 Gbps total usable data transfer rate

# DisplayPort Resolution Capability (Single Display Examples)

| Port Configuration | DisplayPort 1.4a (HBR3) |
|---|---|
| **No Compression** | |
| 4 Lanes, max link rate | 5K (5120x2800)@60fps 24bpp |
| 2 Lanes, max link rate | 4K (3840x2160)@60fps 24bpp |
| **With Compression (DSC)** | |
| 4 Lanes, max link rate | 8K (7680x4320)@60fps 30bpp |
| 2 Lanes, max link rate | 5K (5120x2800)@60fps 24bpp |

Notes:

- 2 Lane configuration is common for USB-C DP Alt Mode
- All above modes assume full 4:4:4 color encoding
- 30bpp is required for DisplayHDR operation

Key:

- DSC = Display Stream Compression
- fps = frames per second
- bpp = bits per pixel

# Optimization for Shared Interface Use

- Numerous specification enhancements to simplify the use of DisplayPort™ as an ingredient in the following interface examples:
  - The USB-C® connector, using the DisplayPort Alt Mode
  - VESA Mobility DisplayPort Standard (MyDP)
  - VESA Embedded DisplayPort Standard (eDP)
  - Thunderbolt™ 3
  - Wireless interfaces

# DisplayPort™ 1.4 Continues to Support Other Features that are Unique to DisplayPort

- Multiple monitors using Multi-Stream
- High-definition audio formats
- Adaptive Sync
- Protocol converters to VGA, DVI, or HDMI
- Low voltage, AC coupled interface compatible with sub-micron process geometry, simplifying integration
- Data scrambling and fixed link rates simplify EMI and RFI mitigation

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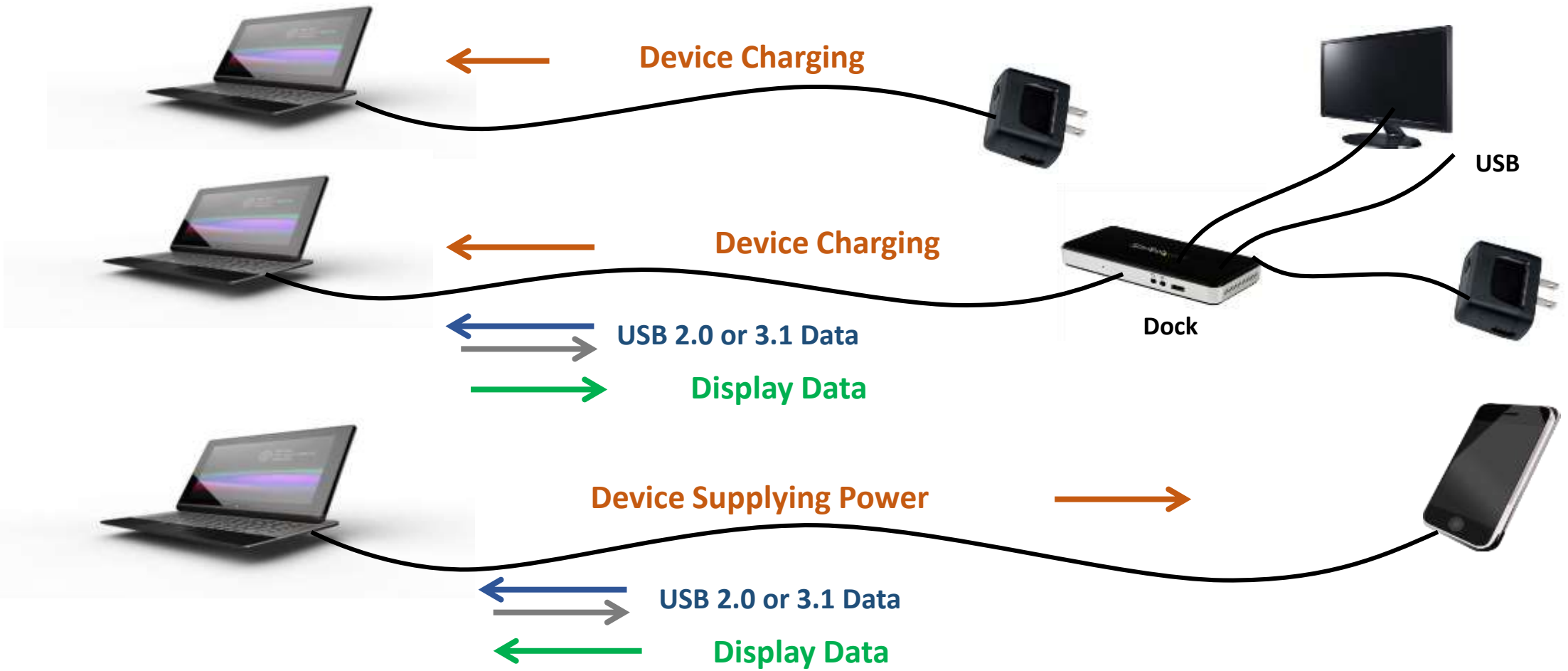
# VESA DisplayPort™ Alternate Mode on USB-C® Summary

- The VESA DisplayPort Alt Mode Standard, Version 1.0b , was released on Nov 3, 2017
- Updates included:
  - incorporation of SCRs to 1.0a
  - Main link AC capacitor value guidance
  - USB-C to DP adapter cable reversibility clarification
  - Clarify Pinout E
  - DP Pwr relaxation
  - Allow optional AC coupling on SS RX

# Example USB Type-C® Configurations

**Either end can serve as USB Host, USB-PD Power Consumer, and DisplayPort™ Video Source (these services are independent of each other**



# DP Alt Mode over USB-C® Ecosystem is Mainstream

USB-C Tablets

USB-C Laptops

USB-C Displays

Multi Function Adapters

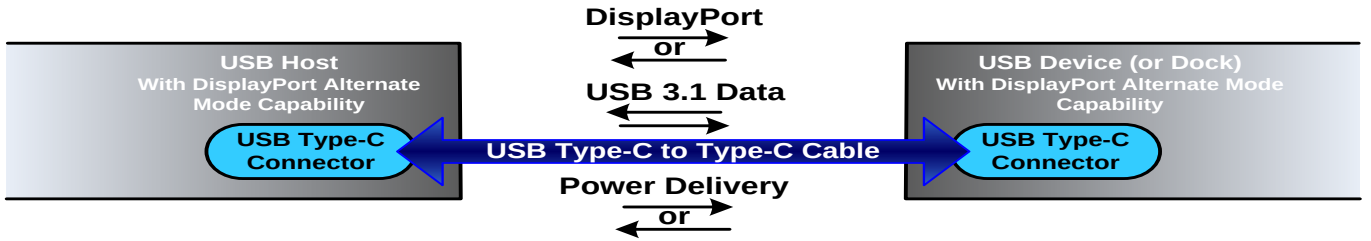
All types of certified adapters available

- USB Type-C to DP adapters, Multifunction docks
- USB Type-C protocol converters (HDMI, VGA, DVI) using DP Alt Mode

More are certified every week

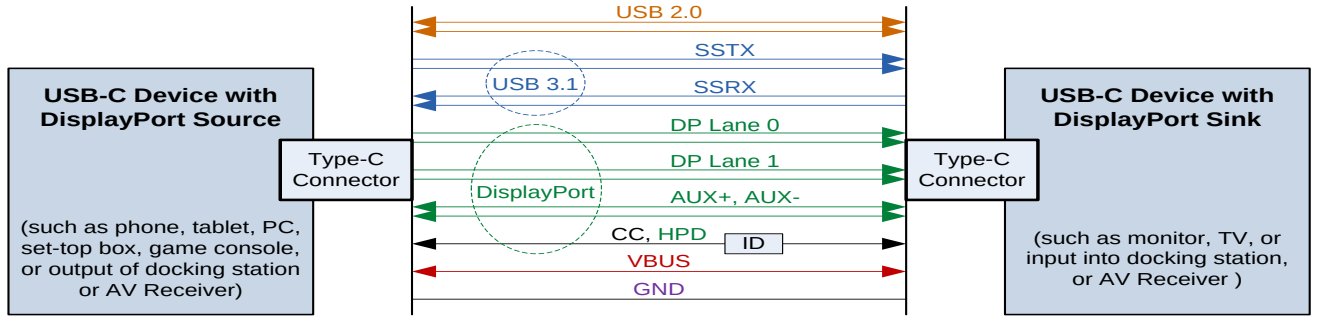
- Major PC OEMs continue to launch new products with DP Alt Mode over USB-C
- Major Display OEMs continue to add USB-C inputs to their products

# USB-C® Connector Functional Extension DP Alt Mode



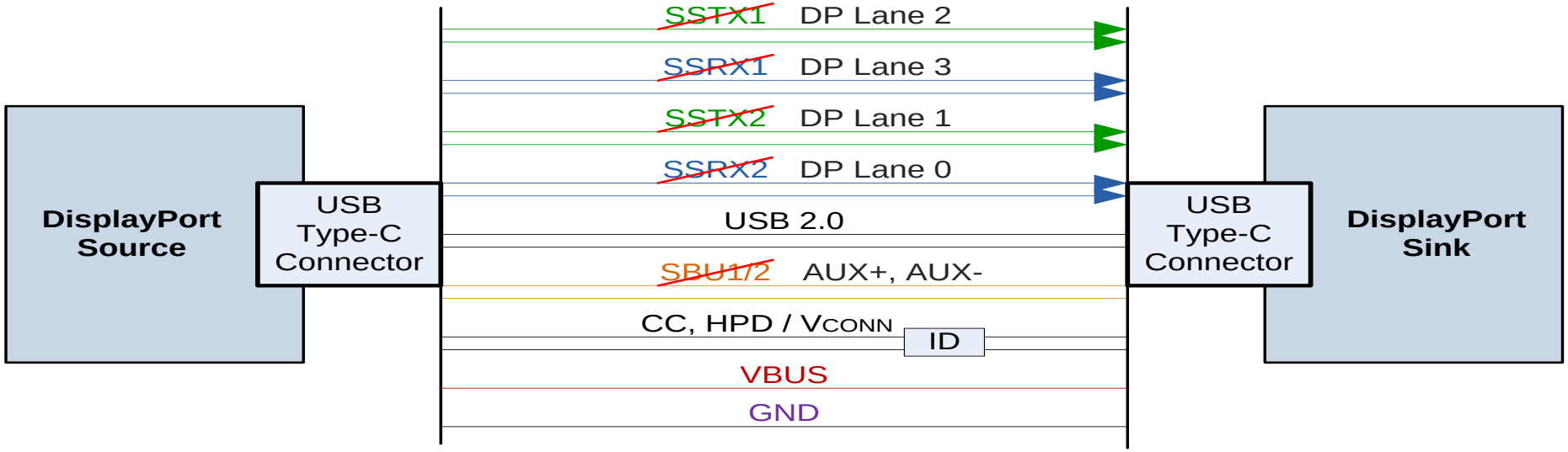

- A passive Full Feature USB Type-C to Type-C cable can carry up to four DisplayPort™ lanes
  - Same performance and features as a standard DisplayPort connection
  - Allows DisplayPort data rates to increase in the future, since the USB Type-C connector has very high data rate capability
- DisplayPort can be combined with USB 3.2 operation over the same USB Type-C cable
- USB 2.0 and USB Power Delivery is available in all configurations

# 2xDisplayPort and USB 3.2 over a Standard USB-C® Cable



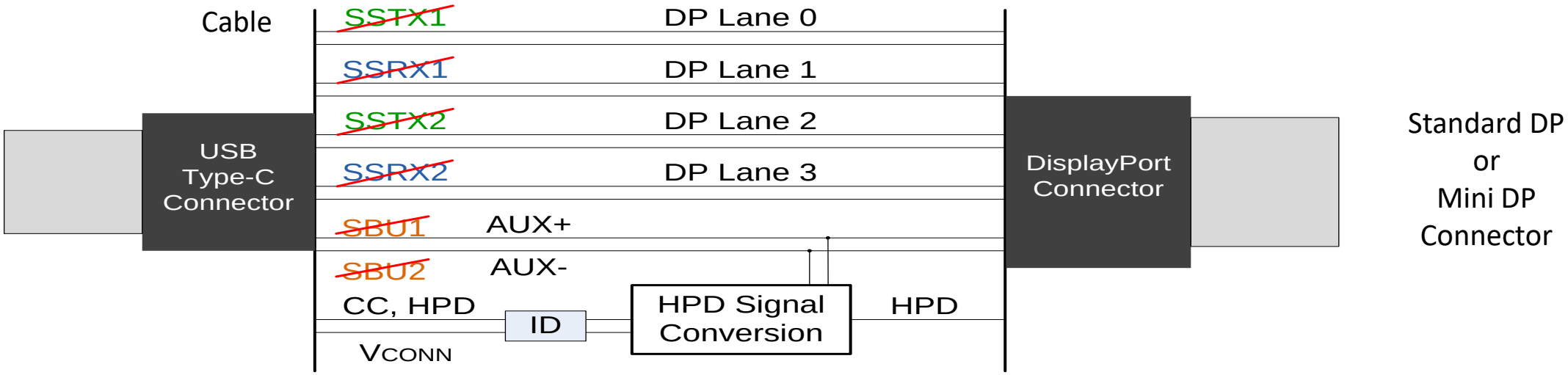

- Uses a standard “Full Feature” USB-C to USB-C cable which is designed to include DisplayPort™
- The above configuration uses two high-speed lanes each for DisplayPort and USB 3.2
  - Ideal for docking stations, or for displays or TVs that include USB 3.2 functions
- DisplayPort performance provided by two lanes
  - DP v1.2 (HBR2 Source devices): Two 1080p displays, or one 4k@30Hz
  - DP v1.4 (HBR3 Source devices): 4K@60, or HDR 4K@60 using 4:2:0 and 12bpp

# 4xDP Over a USB Type-C® to USB Type-C Full Feature Passive Cable



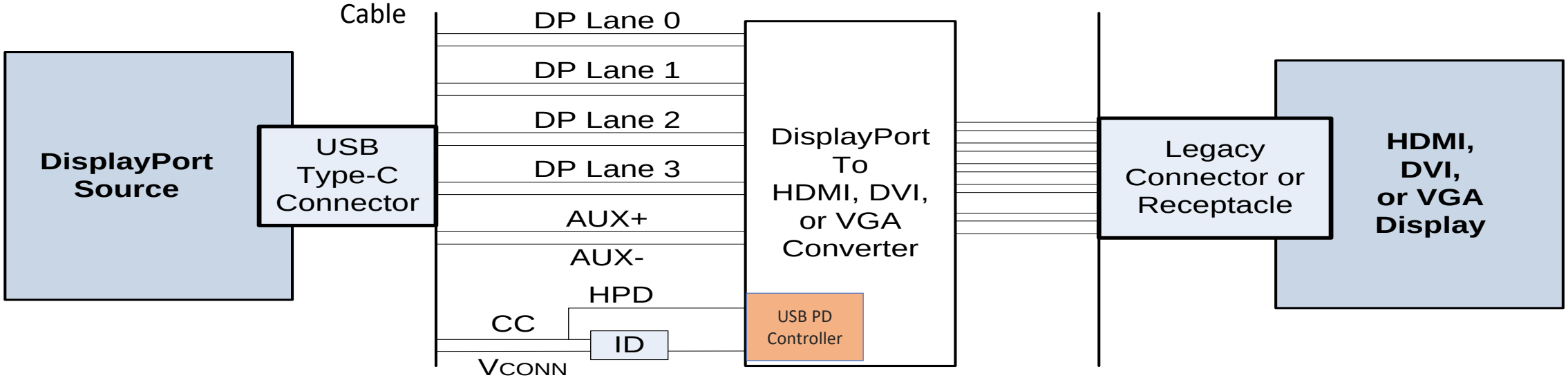

- Utilizes optional DP Alt Mode capability of USB Type-C connector
- DisplayPort™ can use all four high speed lanes to deliver full DisplayPort performance
- The DisplayPort AUX Channel uses the SBU pins
- The DisplayPort HPD / IRQ is transmitted over the CC pin using the USB-PC protocol
- USB 2.0 and USB Power Delivery always available

# USB Type-C® to DisplayPort™ Adapter Cable




- Uses DP Alt Mode capability of USB Type-C connector
- Cable must be reversible, works in either direction; four lanes of DisplayPort
- Supports legacy DisplayPort Source and Sink Devices
- Detected by USB Type-C enabled device that supports DP Alt Mode
- No support for USB (other than USB Billboard) or other alt modes
  - These features are not supported by legacy DisplayPort devices

# USB Type-C® to HDMI, DVI and VGA Adapter Cables / Cable Adapters

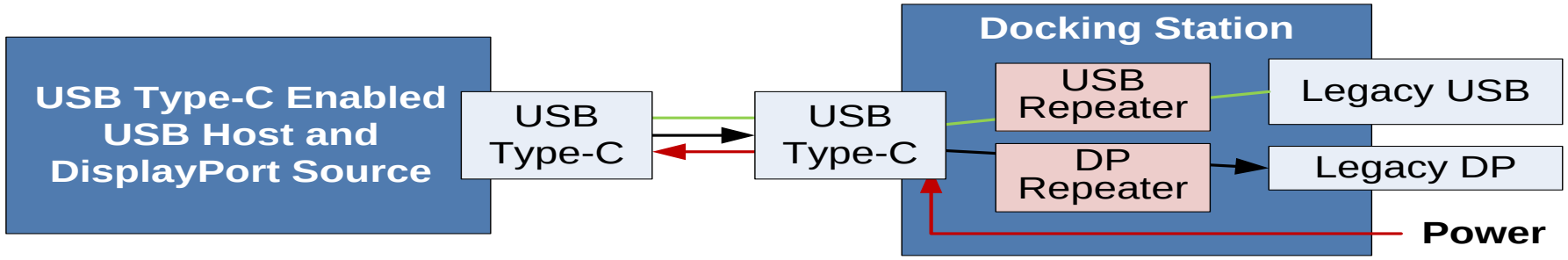



- Uses DisplayPort™ Alt Mode capability of USB Type-C connector
- Adapter Cable: USB Type-C plug on one end, legacy **plug** on other end
- Adapter: USB Type-C plug on one end, legacy **receptacle** on other end
- USB Type-C will NOT support DisplayPort Dual Mode (DP++)
- USB Type-C to HDMI Converters support up to HDMI 2.0b and CEC

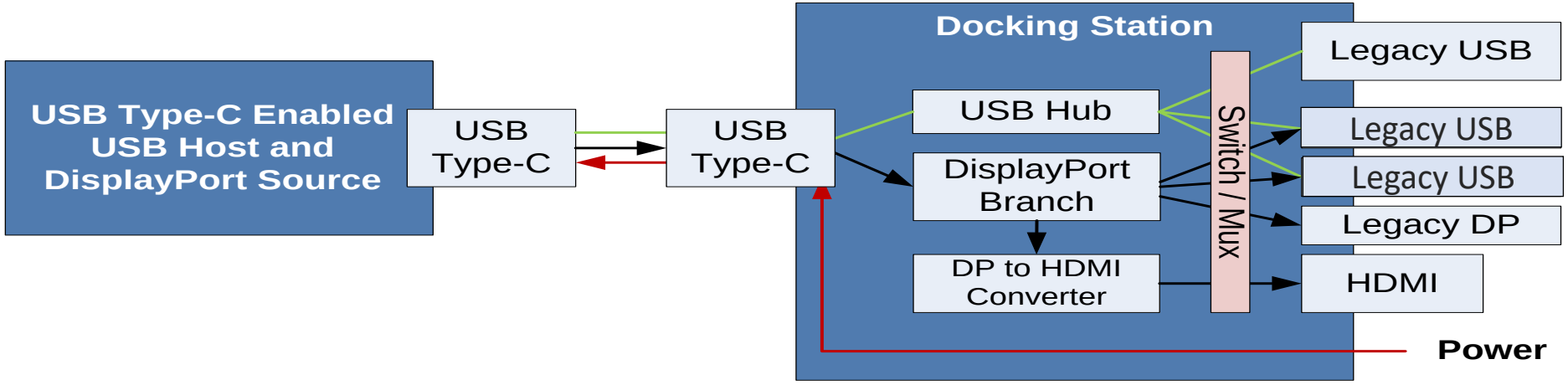
**Both styles are available**

# Example Docking Configurations using the USB Type-C® DisplayPort™ Alternate Mode

## Simple Docking Configuration




## More Complex Docking Configuration



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# DP Alt Mode Compliance Test Specification

- The DP Alt Mode on USB Type-C® CTS Version 1.0, was released Jan 24, 2017.
- Over 200 DP Alt Mode products have been certified over last two years
  - Products include Sources, Sinks, Adapters and Docks

# Certification Test Coverage

Test plan and CTS covers all features and supported pin assignments.

- USB PD Compliance Testing
  - Demonstration of proper functionality/behavior for DP Alt Modes
  - A device must pass DP Alt Mode USB-PD certification tests to receive DP certification
- TX and RX Electrical testing of all supported modes with PHY test fixtures
  - USB PHY electricals
    - USB 3.2 5G
    - USB 3.2 10G (if supported)
    - USB 2.0 480Mb/s
  - DP PHY electricals (DP 1.4a PHY CTS)
    - RBR, HBR, HBR2, HBR3
    - Aux Channel


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# DP Alt Mode Discovery and USB PD Tests

- Section 10 of the DP Alt Mode CTS includes specific USB PD tests for DP Alt Mode products
- These include:
  - DP Alt Mode on USB-C® tests for UFPs
    - Enter Mode Response
    - Status Update Commands
  - DP Alt Mode on USB-C tests for DFPs
    - Discover SVIDs
    - Enter Mode Sequences
    - Status Update
    - Field checks
    - $V_{BUS}$/$V_{CONN}$/HPD timings
- Additional tests have been added to fix issues discovered in the field
  - Pin assignment tests, cable adaptor tests and HPD propagation latency checks
- All tests included in Section 10 must be run in addition to passing USB PD certification by USB-IF

# Certification Test Coverage (continued)

- USB 3.2 Interop testing (functional)
- USB 3.2 Link testing
- DP certification testing
  - Interoperabilty testing
    - Interop testing with a required matrix of products and adapters that are available.
  - Link layer testing
  - EDID testing
  - MST testing if supported
- USB Billboard tests
- Certification testing of USB: VESA requires product vendor provide USB-IF Compliance Test ID

# NEW Compliance Test Areas

- DSC Link Layer Compliance Test Specification SCR v1.0 (July 1, 2019)
  - Adds source and sink DSC compliance tests
  - Support for DSC is mandated in DP v2.0
- DP 1.4a Link Layer Consolidated CTS v1.0 (June 12,2019)
  - Updated tests to meet DP 1.4a requirements
  - Added additional audio and video tests
  - Added FEC source and sink tests. FEC required when DSC enabled
- DP PHY CTS updates
  - VESA DFE tool has been completed
  - Tool created using Matlab and exe provided to PHY TE vendors to solve PHY test correlation issue using DFE

# VESA Synchronization with USB-IF Compliance Test Program

- Coordinate certification plans, test coverage and timing for early products
- Avoid scheduling conflicts
- Avoid testing overlaps and inconsistencies


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# VESA PlugTest Events in 2019

- PlugTests have significant value to member companies. Particularly as new capabilities and products are deployed.
- Product Certification at PlugTests is not feasible due to time constraints.
- VESA will host two PlugTests in 2019.
- Objectives of Plugtests
  - Demonstrate and improve interoperability
    - Particularly important for new product capabilities
  - Test DP 1.4 and DP Alt Mode over USB Type-C® features
  - Verify new test equipment tests and validate test methodologies
  - Verify Test Equipment Correlation
    - PHY, Link and DP Alt Mode USB-PD Testing Correlation
- Dates/Locations:
  - Done: March 2019, Taipei Taiwan
  - Planned : September 30 to October 3, 2019, Embassy Suites Burlingame CA

# Compliance Test Issues

Common compliance testing problems encountered

- DP and DP Alt Mode PHY Compliance
  - PHY TE Correlation of DFE: VESA DP DFE Tool developed to resolve issue
  - TX and RX Low Frequency SJ issue
    - RX testing added JTOL testing at lower frequencies
    - TX testing to include UDJ_LF tests similar to method used by TBT
  - USB 3.2 <-> DP main link crosstalk in Multi-Function config (2xDP, 2xUSB3)
- USB-PD testing issues
  - USB PD 3.0 compliance transition plan
  - New tests added to DP Alt Mode CTS to improve test coverage

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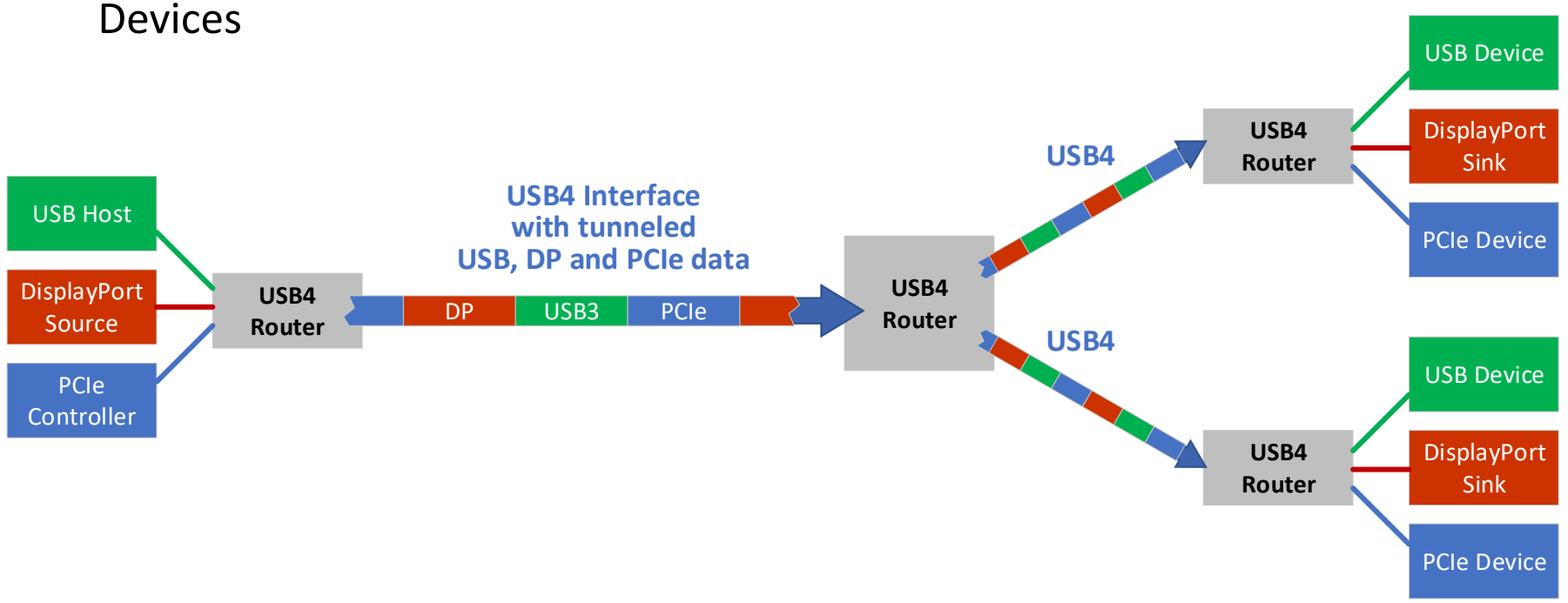
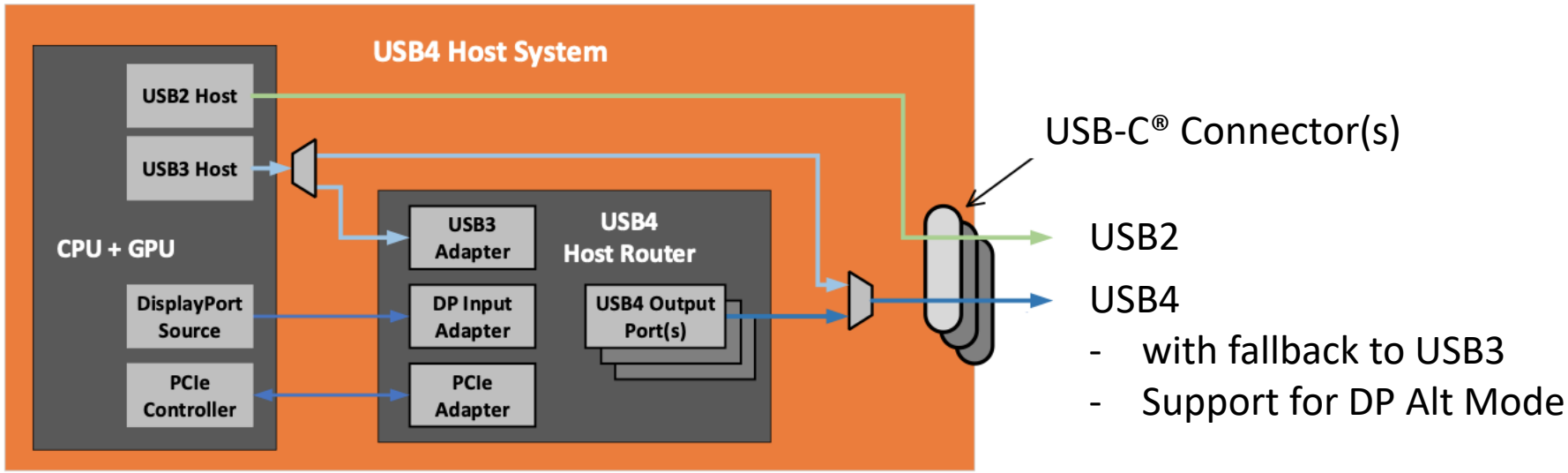
# USB4™ DisplayPort™ Considerations

- This presentation focuses only on USB4 DP requirements. Other requirements are covered in earlier presentations and the USB4 specification.
- There are three USB product types of interest for DisplayPort
- USB4 Host, USB4 Hub and USB4 Device
  - USB4 Hosts and Hubs must support DP Protocol Tunneling, with support optional for USB4 Devices



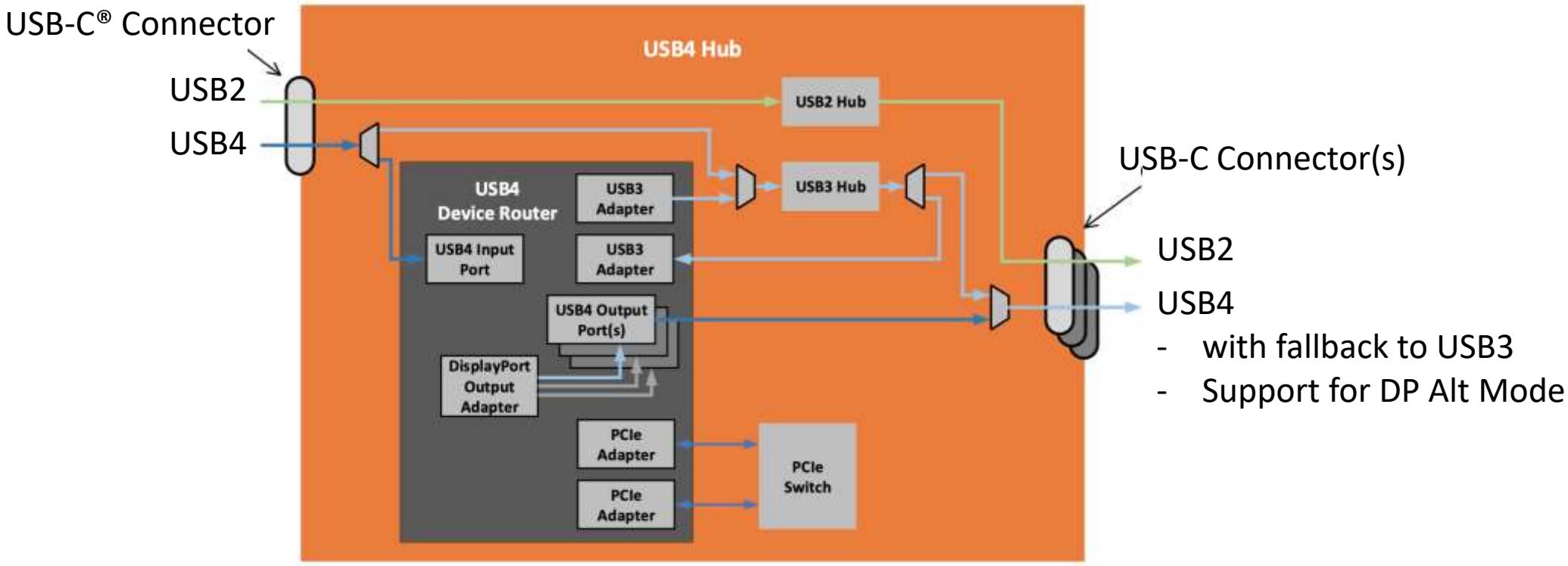
# USB4™ Host – DisplayPort™ Requirements

- USB4 Host DisplayPort requirements are fairly straight forward
- USB4 Host **Must** Support:
  - USB4 Fabric Configuration: Minimum of 2 lanes at 10 Gbps (Gen 2 x 2)
  - USB 3.2 Data Transport, USB 2.0 Native
  - DisplayPort
    - DisplayPort tunneling through USB4
    - DisplayPort Alt Mode on all of it's DFPs



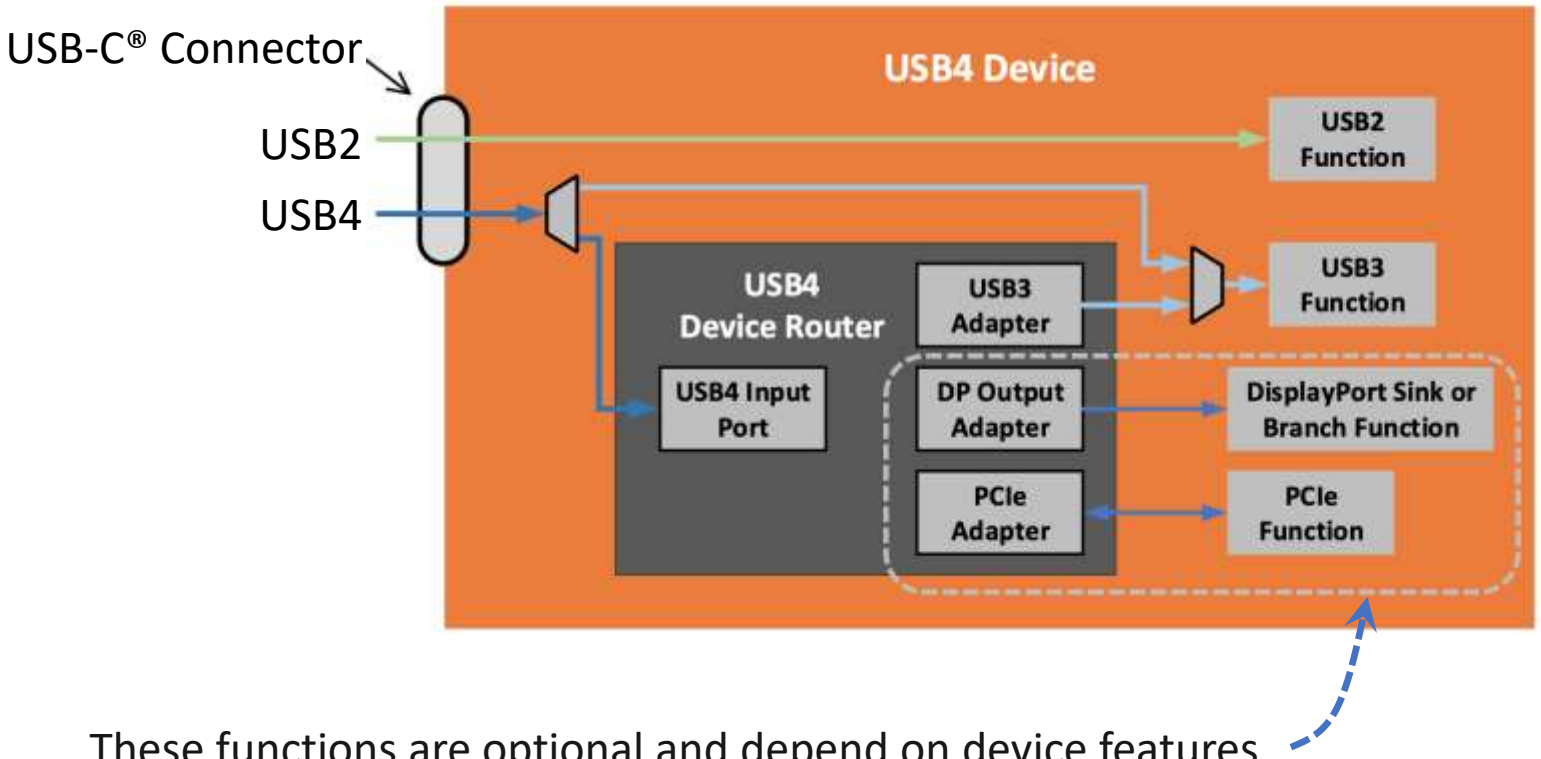
# USB4™ Hub – DisplayPort™ Requirements

- A USB4 hub is required to support DisplayPort Alt Mode on all of its DFPs.
- To connect to DisplayPort Sink, a USB4 hub contains a DP OUT Adapter that receives Tunneled DisplayPort traffic from a USB4 Port and sends it to a DisplayPort Sink via DP OUT Protocol Adapter



# USB4™ Device – w/DisplayPort™ Supported

- A USB4 peripheral device must support 20G USB4 operation (Gen2x2) and optionally 40G USB4 operation (Gen3x2)
- Testing the DP Sink Link Layer will offer new challenges for compliance testing



# Summary

- DP 1.4a products are certified and shipping with these new features.
- These same features will live on into the USB4™ ecosystem from the get-go offering compelling capabilities for end user products.
- Millions of Certified DP Alt Mode over USB-C® products are shipping with many more in development so continued support for backward compatibility is critical, and will be achieved.
- Compliance testing of DisplayPort™ functionality will be complex and will take close collaboration with the USBIF to ensure we get it right.
- DP Alt Mode over USB-C is a huge success and I believe USB4 will accelerate this success to benefit product developers and end users.

# One More Thing…. DP 2.0 Enhancements Improve DP Tunneling Performance with USB4™

- USB4  tunneling architecture is designed to combine multiple protocols onto a single physical interface.
- DP v2.0, released June 26, 2019, includes many enhancements that will improve USB4 DP Tunneling performance.
  - New UHBR rates increases the per-lane bandwidth to 3x of HBR3
    - Raw lane rate increase plus channel coding efficiency improvement leveraging USB4 PHY
  - **DSC support mandated** that reduces the isochronous DP bandwidth, enabling allocation of more USB4 bandwidth to other functions
  - **Panel Replay** based on Panel Self Refresh of eDP, reducing the isochronous DP bandwidth when enabled, providing more USB bandwidth to other functions
- For DP Alt Mode over USB-C®, DP 2.0 carried over the USB-C connector enables simultaneous higher-speed USB data transfer while offering 3x display transport performance.

# Questions?




VESA DisplayPort

# VESA Links

- https://vesa.org/
- https://www.displayport.org/
- https://displayhdr.org/

# *Time for Q&A*