VESA – DisplayPort™ Alternate Mode on USB-C®

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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
VES A Standards Enable Many Market Segments...

- Monitors, PCs and laptops
- Smartphones and tablets
- Gaming consoles and headsets
- Automotive
- Digital projectors
- Digital signage / kiosks
...As Well as Many Aspects of Display Technology

**Display Interfaces**
- DisplayPort
- DisplayPort over USB-C (DisplayPort Alt Mode)
- Embedded DisplayPort

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

**High Dynamic Range**
- DisplayHDR

**Display Capability Parameters**
- DisplayID
- Extended Display Identification Data (EDID)
- Multi-Display Interface
VESPA Membership Continues to Grow

![Membership Chart]

- August 2017: 258 members
- September 2017: 260 members
- October 2017: 265 members
- November 2017: 268 members
- December 2017: 271 members
- January 2018: 272 members
- February 2018: 272 members
- March 2018: 272 members
- April 2018: 275 members
- May 2018: 278 members
- June 2018: 280 members
- July 2018: 276 members
- August 2018: 280 members
- September 2018: 281 members
- October 2018: 282 members
- November 2018: 278 members
- December 2018: 274 members
- January 2019: 282 members
- February 2019: 276 members
- March 2019: 275 members
- April 2019: 287 members
- May 2019: 291 members
- June 2019: 288 members
- July 2019: 288 members
Historical Membership by Region

10 Year Flip from US to Asia Dominant

- **Europe**
  - 2008: 8%
  - 2014: 9%
  - 2016: 10%
  - 2018: 10%

- **US**
  - 2008: 51%
  - 2014: 48%
  - 2016: 37%
  - 2018: 36%

- **Asia**
  - 2008: 41%
  - 2014: 43%
  - 2016: 53%
  - 2018: 54%
VESPA Asia Membership

Asia Member Distribution of 150 Members

- Japan: 38%
- South Korea: 32%
- China: 21%
- Taiwan: 9%
VES A 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](mailto: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

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

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)

<table>
<thead>
<tr>
<th>Port Configuration</th>
<th>DisplayPort 1.4a (HBR3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Compression</strong></td>
<td></td>
</tr>
<tr>
<td>4 Lanes, max link rate</td>
<td>5K (5120x2800)@60fps 24bpp</td>
</tr>
<tr>
<td>2 Lanes, max link rate</td>
<td>4K (3840x2160)@60fps 24bpp</td>
</tr>
<tr>
<td><strong>With Compression (DSC)</strong></td>
<td></td>
</tr>
<tr>
<td>4 Lanes, max link rate</td>
<td>8K (7680x4320)@60fps 30bpp</td>
</tr>
<tr>
<td>2 Lanes, max link rate</td>
<td>5K (5120x2800)@60fps 24bpp</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Cable</th>
<th>USB Type-C Connector</th>
<th>DisplayPort Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DP Lane 0</td>
<td>Aux+</td>
</tr>
<tr>
<td>SSTX</td>
<td>DP Lane 1</td>
<td></td>
</tr>
<tr>
<td>SSRX</td>
<td>DP Lane 2</td>
<td></td>
</tr>
<tr>
<td>SSTX2</td>
<td>DP Lane 3</td>
<td></td>
</tr>
<tr>
<td>SSRX2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBU1</td>
<td></td>
<td>HPD</td>
</tr>
<tr>
<td>SSTX2</td>
<td></td>
<td>HPD Signal Conversion</td>
</tr>
<tr>
<td>SBU2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC, HPD</td>
<td>ID</td>
<td></td>
</tr>
<tr>
<td>VCONN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard DP or Mini DP Connector
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
Example Docking Configurations using the USB Type-C® DisplayPort™ Alternate Mode

Simple Docking Configuration

More Complex Docking Configuration
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• DisplayPort Alternate Mode on USB-C®
• **Compliance Testing**
• USB4™ DisplayPort™ Considerations
• Summary
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
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
    • VBUS/VCONN/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
  - Interoperability 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
VESASynchronizationwithUSB-IFComplianceTestProgram

• Coordinate certification plans, test coverage and timing for early products
• Avoid scheduling conflicts
• Avoid testing overlaps and inconsistencies
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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- Compliance Testing
- **USB4™ DisplayPort™** Considerations
- Summary
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 its DFPs

![USB4 Host System Diagram]

- USB2 Host
- USB3 Host
- DisplayPort Source
- PCIe Controller
- CPU + GPU
- USB-C® Connector(s)
- USB2
- USB4
  - with fallback to USB3
  - Support for DP Alt Mode
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.

- with fallback to USB3
- Support for DP Alt Mode
### 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

These functions are optional and depend on device features.
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?

DisplayPort over USB-C
The most advanced display connection now uses the most versatile connector.

Learn More Go to www.displayport.org
VESA Links

• https://vesa.org/
• https://www.displayport.org/
• https://displayhdr.org/
Time for Q&A