VESA – DisplayPort™ Alternate Mode on USB-C™ - Technical Overview

Jim Choate
VESA Compliance Program Manager

Houston
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Agenda

• Introduction
• DisplayPort Technology Roadmap
• DisplayPort Alternate Mode on USB-C Technical Overview
• Compliance
• Demo
• Summary
About VESA

VESAs the Video Electronics Standards Association (VESA) is a global industry alliance with more than 230 member companies. Its mission is to develop, promote, and support an ecosystem of vendors and certified interoperable products for the electronics industry. This is achieved by facilitating display-related standards development, publication, and compliance testing, as well as promotion and marketing. VESA develops Open standards, and contribution is open to all companies at all stages of development.
Example of VESA Members
## Display Trends and DisplayPort Roadmap

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<td><strong>Notebook PC</strong></td>
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<td>1680x1050</td>
<td>1080p</td>
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<tr>
<td><strong>Link Rate per Lane</strong></td>
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<tr>
<td>DP 1.0-1.1</td>
<td>Up to Quad HD</td>
<td>DP 1.2</td>
<td>Up to 4K 60Hz, 10 bit color</td>
<td>DP 1.4</td>
<td>Up to 8K</td>
<td>DP 1.3</td>
<td>Up to 5K</td>
<td>DP XX</td>
<td>Up to 8K 120Hz</td>
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<tr>
<td>2.7 Gbit/sec</td>
<td>5.4 Gbit/sec</td>
<td></td>
<td>8.1 Gbit/sec</td>
<td>10 Gbit/sec</td>
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</table>

*You are here*
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
- New Silicon supporting HBR3 is under deployment and certification testing has started
- DisplayPort 1.4 New Features
  - Forward Error Correction
  - Adds 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  
× 0.8  to account for 8b/10b transport coding overhead  
× 4  maximum number of available lanes  
25.92 Gbps total usable data transfer rate
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 DockPort Standard
  • VESA Mobility DisplayPort Standard (MyDP)
  • VESA Embedded DisplayPort Standard (eDP)
  • ThunderBolt 3.0
  • 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
Progression of Display Experience with DisplayPort

**DP 1.0/1.1 (4/2007) – HBR1**
- A setup driven by 6 Mini-DP connectors at 2560x1600@60Hz on single graphics card

**DP 1.2 (12/2009) – HBR2**
- UHD – 4K
- 30 bit color; 3840x2160@60Hz
- Tiled Display: 4Kx2K single cable
- Tiled Display: 5Kx3K Dual Cable
- AdaptiveSync

**DP 1.3 (9/2014) – HBR3**
- HDR, PQ Gamma, BT 2020
- HDCP 2.2, 420
- Tiled Display: 8K 444 Dual Cable
- 5Kx3K@60 and 4K@120Hz Single Cable
- Single cable for DP A/V, power and data using DP Alt Mode on USB-C

**DP 1.4 (3/2016) – HBR3 & DSC**
- UHD – 8K
- 30b color; 8K 444 (7680x4320) @60Hz – Single Cable
- VR – 4K + 120Hz + USB3.1 + Pwr
- Multi Display Docking with DP Alt Mode on USB-C
- Dynamic HDR Meta
DisplayPort Alternate Mode on USB-C Overview and Certification
VESAA DisplayPort Alternate Mode on USB-C Summary

• The VESA DisplayPort Alt Mode Standard, Version 1.0a, was released on Aug 10, 2015
• Enables the use of the USB-C interface for DisplayPort
• DisplayPort Alternate Mode is a functional extension of the USB-C interface
• Developed in liaison with the USB 3.0 Promoter Group
• The DisplayPort Alternate Mode over USB-C Compliance Test Specification draft is under General Member Review with expected release next quarter
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)

- Device Charging
- USB 2.0 or 3.1 Data
- Display Data
- Device Supplying Power
USB-C with DP Alt Mode Ecosystem Deployment Underway

DP Alt Mode Products

- Apple MacBook
- HP Pro Tablet 608 G1
- Dell XPS 13/15
- LG 27UD88 4K display
- StarTech 4 in 1 Adapter
- Google Chromebook Pixel
- Microsoft Lumia 950 and 950XL Smartphones
- LG G5

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

More are expected soon
- Major PC continue to launch new products with DP Alt Mode over USB-C
- Thunderbolt includes USB 3.1 + DP Alt Mode as standard compatibility modes
Wide Range of Cables/DP Alt Mode Adapters Shipping Today

These adapters enable the use of the vast installed base of legacy displays for the increasing numbers of systems that support DisplayPort Alternate Mode over USB-C.
USB-C Connector Functional Extension
DisplayPort Alternate 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 3.1 operation over the same USB Type-C cable

• USB 2.0 and USB Power Delivery is available in all configurations
USB Type-C Receptacle Pins

• Below is a diagram of the pins defined for system or device receptacle
DisplayPort and USB 3.1 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 3.1
  - Ideal for docking stations, or for displays or TVs that include USB 3.0 functions
- DisplayPort performance provided by two lanes
  - DP v1.2 (existing 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
- 4 Lanes of DisplayPort available if only USB 2.0 implemented in Sink
  - Support for 4K@60, or two 2560x1600, or four 1080p
Example USB-C PHY Port Configuration Switch for Systems with DisplayPort Source

- Equalization and re-drivers for the SS USB and DisplayPort signals increase margins
- Compensates for loss in PCB traces and switch, increases system design flexibly and compliance margin
- Routes signals according to plug orientation and use of SS USB and/or DP
- Similar switch needed at source side
Supported cable types
• USB-C to USB-C
• USB-C to DP
• USB-C to Protocol converter
• USB-C to Docking station or embedded hub solution
• USB-C to DP cables must include logic to support USB PD and DP connection detect protocols.

• Protocol converters must support some optional features in DP 1.3 specification
  • Protocol converters translate source DP signals to the respective protocol supported
DisplayPort Over a USB Type-C to USB Type-C Full Feature Passive Cable

- Utilizes optional DisplayPort 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 DisplayPort 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 2.0 and CEC

Both styles are available
Example Docking Configurations using the USB Type-C DisplayPort Alternate Mode

**Simple Docking Configuration**

- USB Type-C Enabled USB Host and DisplayPort Source
- USB Type-C
- USB Repeater
- Legacy USB
- Legacy DP

**More Complex Docking Configuration**

- USB Type-C Enabled USB Host and DisplayPort Source
- USB Type-C
- DisplayPort Branch
- DP to HDMI Converter
- USB Hub
- Legacy USB
- Legacy USB
- Legacy DP
- HDMI

Power
DisplayPort Alternate Mode Compliance Test Plan

• VESA is developing the DP Alternate Mode compliance test in coordination with the USB-IF

• Compliance test specification (CTS) is under general membership review
  • Draft 1.0 expected to release next quarter

• The objective is to enable compliance testing for USB Type-C, and the DP Alt Mode for USB Type-C, at the same ATCs enabling the use of a single test station

• Certification of many DisplayPort Alternate Mode enabled products is in progress at GRL and Allion ATCs
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 DisplayPort Alt Mode USB-PD certification tests to receive DP certification

- **Electrical testing of all supported modes with PHY test fixtures**
  - **USB PHY electricals**
    - USB 3.1 Gen1 5G
    - USB 3.1 Gen2 10G (if supported)
    - USB 2.0 480Mb/s
  - **DP PHY electricals (DP 1.2b CTS)**
    - RBR
    - HBR
    - HBR2 (HBR3 compliance requirements under development)
    - Aux Channel
Certification Test Coverage (continued)

- USB 3.1 Interop testing (functional)
- USB 3.1 Link testing
- Full DP certification testing using reference Adapters
  - Interoperability testing
    - Interop testing with a required matrix of products and adapters that are available.
    - Testing with reference USB-C to DP adapters is required.
    - Testing with reference DP Alt Mode over USB-C reference sources and sinks is required.
  - Link layer testing
  - EDID testing
  - MST testing if supported
- Certification testing of USB 3.1 functionality not duplicated if product vendor provides VESA USB-IF Compliance Test ID
Cable & Adapter testing

- Certification testing of cables/adapters
- USB-C to USB-C cables certified via USB-IF
- USB Type C to DP cable
  - Electrical testing
  - Interoperability testing
  - Link Layer testing
- Protocol converters (all protocol converters are DP sinks)
  - Receiver testing
  - USB PD testing
  - Link Layer Sink tests
  - Interoperability tests
VESAs Synchronization with USB-IF Compliance Test Program

- Coordinate certification plans, test coverage and timing for early products
- Avoid scheduling conflicts
- Participate in USB-IF certification and interoperability events
- VESA will continue to participate in USB-IOP events and workshops
VESAs PlugTest Events in 2016

• PlugTests have significant value to member companies. Particularly as new capabilities and products are deployed.
• VESA planned to host three PlugTests in 2016. The third event this year is in Taiwan.
• November Taiwan event introduced workshop pre-cert testing

• Objectives of 2016 Plugtests
  • Demonstrate and improve interoperability
    • Particularly important for new product capabilities
  • Test DP 1.4 and DP Alt Mode over USB Type-C
  • Verify Test Equipment Correlation

• Dates/Locations:
  • Done: March 23-26th 2015, Milpitas CA
  • Done: September 14th-17th 2015, Embassy Suites Burlingame CA
  • Planned: Taiwan December 12-16th, Westin Taipei
Logo Useage Guidelines

• No change to existing DP product logo guidelines
• For DP over USB-Type C products
  • DP certification includes subset of testing requirements of USB-IF
  • Requirement to use new fixtures and DP over USB Type-C adapters
• Refer to VESA DisplayPort logo usage guidelines for further information
• Refer to the USB-IF Trademark License Agreement for further information
• VESA is working with the USB-IF to create additional logo guidelines as well as common product description terminology
Compliance Test Issues

Common compliance testing problems encountered

• DP Alt Mode PHY Compliance
  • OS specific toolset are often required to properly get into test modes
  • Some products/chipsets do not support Test Automated over Aux
  • This is being addressed in new methodology under developer, the Link Training Test Automation Mode.

• USB-PD testing issues
  • Specification has been changing
  • New tests added to draft CTS have uncovered implementation issues
  • DP Alt Mode CTS USB-PD Test 10.1.2 Status update Command Test failures. The test fails if the Status field is invalid
  • A number of other issues have been identified at recent USB-IOP events and VESA PlugTest events. Tests will be added to verify product compliance.
Compliance Test Issues

• 1 or 2 lane configuration compatibility issues

• Source and sink chipset issues uncovered during interoperability testing of DP Alt Mode products using USB-C docks.
  • Issue occurs when Dock is configured in 2 lane mode to support 2 lanes of DP and 2 lanes for USB 3.1
  • Sources fail if they don’t implement fallback rules in DP 1.4 specification
  • Sinks fail if they don’t support reduced lane operation or if they don’t correctly report CR and/or Link EQ/Alignment failures on unconnected lanes
  • Billboard implementations: many products have not updated to Billboard latest requirements
  • Compliance tests are under development to address these issues
Billboard Compliance Testing

- Download USB3CV from USBIF developers page
- X32 or X64
- Install on system with xHCI (no Alt Mode Support)
- Select Billboard tests and run

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DP Alt Mode PHY Testing

Test Setup for DP PHY testing using DP Aux Test Automation

Connector: DP or mDP

Connector: Type C

Keysight TPAs

Fixtures

DP TPAs

DP PHY test

AUX PHY test

DP cable

Aux Reference Controller

AUX Automation

Unigraf DPR-100

AUX Automation

Test Setup for DP PHY testing using Link Training Test Automation

September 27 – 28, 2016 USB Implementers Forum © 2016
## Summary of DP Alt Mode over USB-C supported features

<table>
<thead>
<tr>
<th>Feature</th>
<th>DisplayPort Alt Mode</th>
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<tbody>
<tr>
<td>Supports HDMI 1.4b displays</td>
<td>✓</td>
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<tr>
<td>Supports 4K 30 Hz displays</td>
<td>✓</td>
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<tr>
<td>No adapter required for connection from USB Type-C to standard HDMI TV</td>
<td>✓</td>
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<tr>
<td>Supports HDMI 2.0 displays</td>
<td>✓</td>
</tr>
<tr>
<td>Supports 4K 60 Hz displays</td>
<td>✓</td>
</tr>
<tr>
<td>Supports High Dynamic Range</td>
<td>✓</td>
</tr>
<tr>
<td>Supports multiple video streams</td>
<td>✓</td>
</tr>
<tr>
<td>Connects to USB-C enabled displays that are shipping now (DisplayPort Alt Mode enabled)</td>
<td>✓</td>
</tr>
<tr>
<td>Supports USB SuperSpeed concurrent with video display</td>
<td>✓</td>
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<tr>
<td>Supports simple adapter for connection to existing HDMI cables</td>
<td>✓</td>
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<tr>
<td>Avoids rewiring of pre-installed HDMI cables</td>
<td>✓</td>
</tr>
<tr>
<td>Supports HDR</td>
<td>✓</td>
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<tr>
<td>Supports 4K 60 Hz full color (4:4:4)</td>
<td>✓</td>
</tr>
<tr>
<td>Supports 4K 60Hz deep color</td>
<td>✓</td>
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<tr>
<td>Supports multiple 4K videos</td>
<td>✓</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>DisplayPort Alt Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports High Dynamic Range</td>
<td>✓</td>
</tr>
<tr>
<td>Supports 4K high refresh rate (120Hz)</td>
<td>✓</td>
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<tr>
<td>Supports 8K video (with HBR3 plus DSC)</td>
<td>✓</td>
</tr>
<tr>
<td>Low latency interactive VR experience with 90+ 4K+ with DP + USB 3.0</td>
<td>✓</td>
</tr>
<tr>
<td>Supports USB Type-C on TV</td>
<td>✓</td>
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<tr>
<td>Runs on USB Type-C to USB Type-C cables</td>
<td>✓</td>
</tr>
<tr>
<td>Connects to wide range of already deployed USB-C devices</td>
<td>✓</td>
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<tr>
<td>Use Cases</td>
<td></td>
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<tr>
<td>Multi 4k display productivity with single cable docking</td>
<td>✓</td>
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<tr>
<td>Low latency Interactive VR experience with dual 4K&gt;90Hz + Power + USB 3.1 (HBR3+DSC)</td>
<td>✓</td>
</tr>
<tr>
<td>Smooth low latency gaming with AdaptiveSync</td>
<td>✓</td>
</tr>
<tr>
<td>8k HDR workstation productivity with DP + DSC</td>
<td>✓</td>
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</tbody>
</table>

**DisplayPort 1.4 along with DP Alt Mode over USB-C & DSC can do today what you want your products to do tomorrow.**
Demos
Summary

• DP 1.4 introduced many new capabilities and products are under development and in the certification process for these new features

• Many Certified USB-C devices with DP Alt Mode are shipping with many more in development

• DP Alt Mode CTS is under General Member Review and will be published by VESA in Q4’2016.

• DP Alt Mode device certification is available from certified ATCs since 2015, allowing use of DP logo

• Final 2016 VESA PlugTest event is in Taiwan December 12-16th 2016
Questions?

DisplayPort over USB-C

The most advanced display connection now uses the most versatile connector.

Learn More  Go to www.displayport.org