DisplayPort Technology Update

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June 15, 2016

Agenda

- **VESA Overview**
- DisplayPort™ 1.4
- Why you need DisplayPort Early Certification and Allion's update for DP 1.4
- DisplayPort over USB-C™ Overview
- DisplayPort over USB-C™ Certification
- GRL's Experience in DisplayPort over USB Type-C (tm) Testing
- Summary

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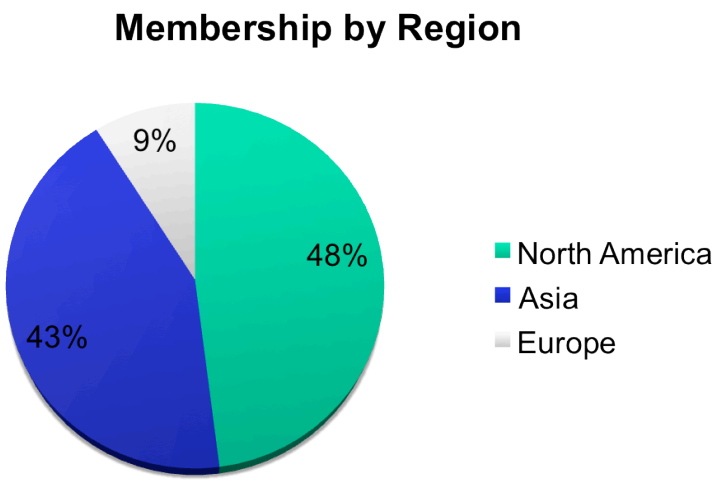
About VESA

- Global industry alliance with more than 230 member companies



- Mission to develop, promote and support ecosystem of vendors and certified interoperable products for the electronics industry

- Facilitate DisplayPort standards development, publication and compliance testing, as well as promotion and marketing

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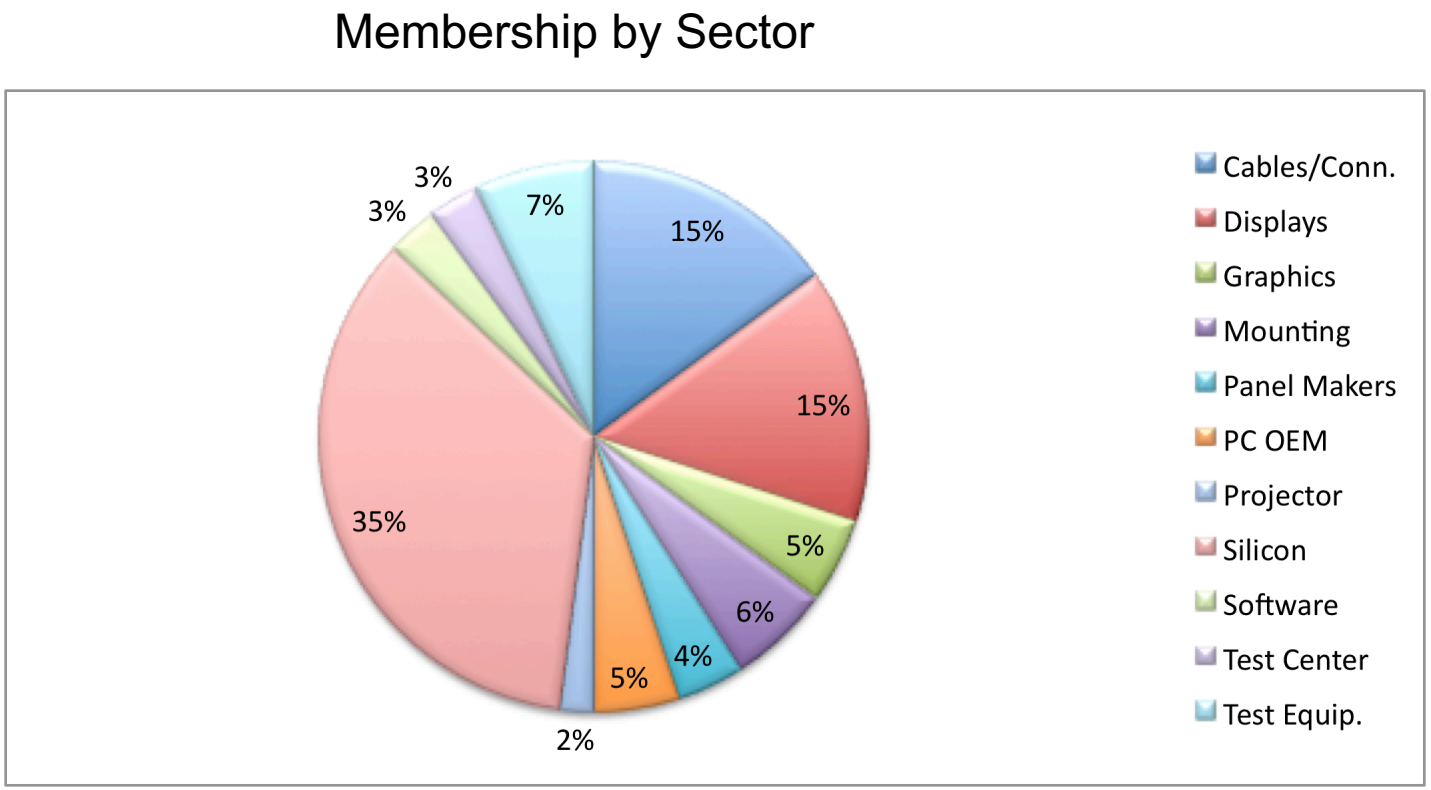
VESA Membership is Diverse



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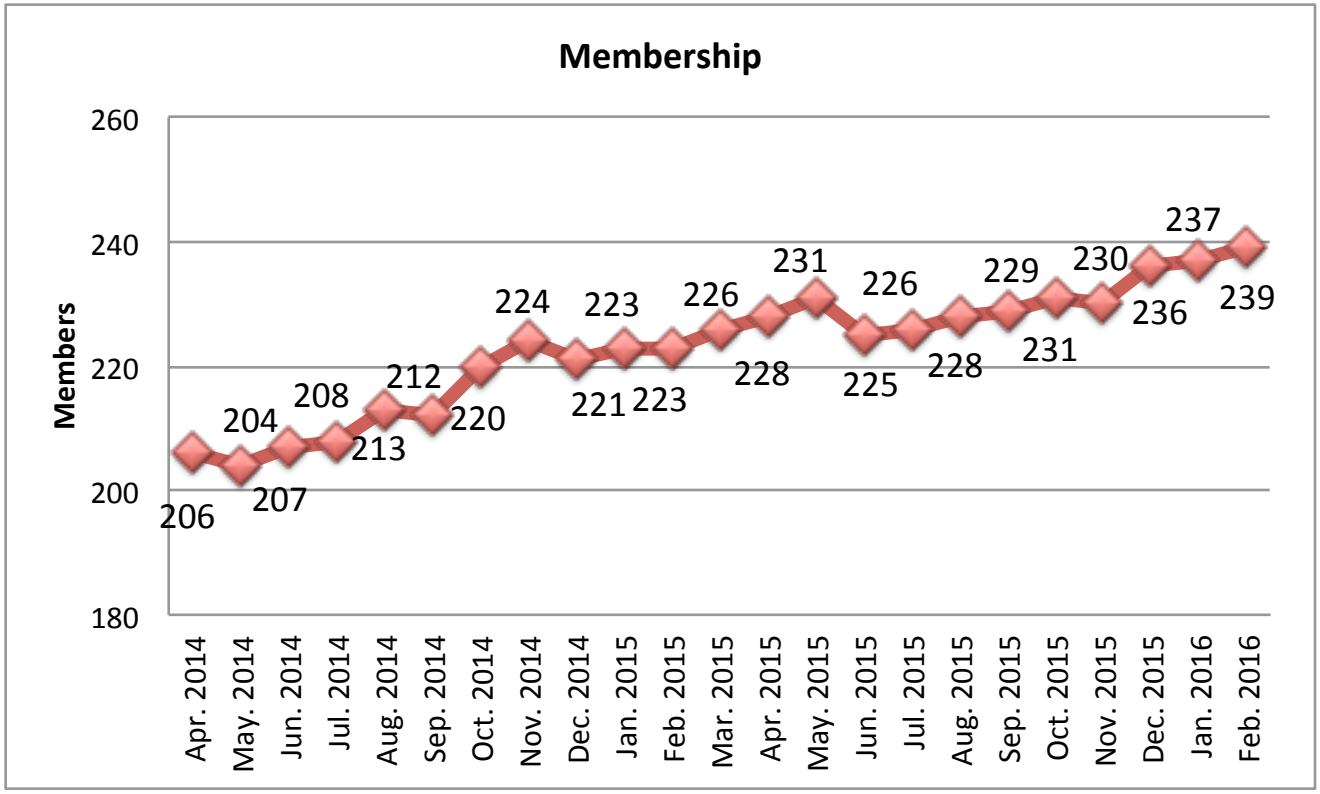
Quick Fact

VESA Membership Continues to Grow!



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Overview of Base DisplayPort Standard

- Starting ~2005, major suppliers in the personal computer industry set off to define the next generation display interface
  - PC, Display, Semiconductor and Connectivity OEMs drove development
- Overall objectives
  - Open standard, contribution open to all companies
  - Future proof in both performance and features
  - Applicable over a wide range of applications
- Development was done within the Video Electronics Standards Association
  - None-disclosure and IP policies protect contributing companies when presenting new technology and provide a productive work environment

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DisplayPort 1.4 Summary

- The VESA DisplayPort Standard, Version 1.4, was released on February 23, 2015
- Adds new features and capabilities such as Display Stream Compression (DSC), Forward Error Correction (FEC) and enhanced Multi-Stream Transport (MST) feature
- Backward compatible, offers new optional features
- New Silicon supporting HBR3 and new features are under development
- Compliance testing expected during second half of 2016

DP 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	HBR 2	5.4 Gbps	4K x 2K	Not supported
DP 1.3/1.4	HBR 3	8.1 Gbps	5K x 3K	8K x 4K

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

Optimization for Shared Interface Use

- Numerous specification enhancements to simplify the use of DisplayPort as an ingredient in the following interface examples:
  - The USB Type-C connector, using the DisplayPort Alt Mode
  - VESA DockPort Standard
  - VESA Mobility DisplayPort Standard (MyDP)
  - VESA Embedded DisplayPort Standard (eDP)
  - ThunderBolt
  - Future 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
- **Royalty free standard** available to VESA members

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Expected DisplayPort 1.4 Deployment

- HBR3 (32.4 Gbit/s) as introduced in version 1.3 still remains the highest available mode
- DP 1.4 is expected to be enabled in both native DP devices and devices using the USB Type-C interface with the DisplayPort Alternate Mode
- DP 1.4 Devices are under development today
- DisplayPort-to-HDMI 2.0 converters are available today
- DP 1.4 CTS development has begun
  - Tests under development cover HBR3, DSC, FEC and HPD/IRQ_HPD response testing

VESA PlugTest Events

- PlugTests have significant value to member companies. Particularly as new capabilities and products are deployed.
- VESA hosted three successful PlugTests in 2015
- VESA plans to host three PlugTests in 2016

Objectives of 2016 PlugTests

- Demonstrate and improve Traditional Interoperability
  - Particularly important for new product capabilities
- Test DP 1.4 and DP Alt Mode over USB Type-C™ products
  - HBR3 and other new capabilities
- Verify Test Equipment Correlation
- Dates/Locations:
  - Done: March 21-24th 2016, Taipei Taiwan
  - Scheduled: September 12-16, 2016 Burlingame CA
  - TBD: Taiwan/US November 2016?

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Top DP Compliance Test Issues

- Reduced Lane Fallback Requirements
  - DP 1.4 clarified reduced lane count fallback requirements
  - GRL and Allion have been performing informative tests for last 6 months
  - QD and Unifgraf have implemented tests
  - Will require as certification test in 2017
- Link Training PHY test automation
  - Working on new test methodology for testing PHY during link training
  - Will be part of PHY 1.4 CTS
- HBR3 Compliance Testing
  - Test tools and CTS are being updated to support HBR3 products when they are ready
  - Plan is to create “early product certification plan” for early adopters

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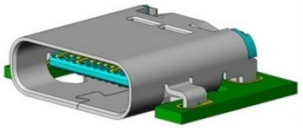
DisplayPort Over USB-C Summary

- The *VESA DisplayPort Alt Mode Standard, Version 1*, was released on Sept 22, 2014
- Enables the use of the USB Type-C interface for DisplayPort



- Alternate Mode functional extension of the USB Type-C interface
- Developed in liaison with the USB 3.0 Promoter Group

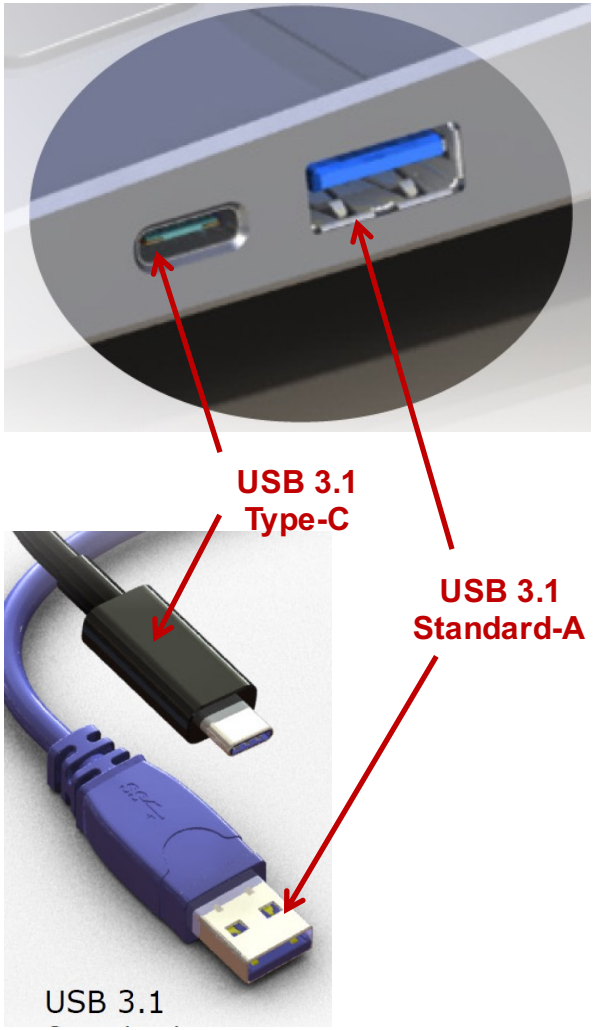
Introduction of USB Type-C

USB Type-C information is provided as an informative overview only, please refer to the USB Type-C Cable and Connector Specification available at www.usb.org for more information

- New generation of USB connector developed to serve the market for next 20 years
- Thin profile suitable for both ultra portable devices and larger devices
- Reversible plug orientation & cable direction
  - USB 3.1 Gen 2 (10Gbps)
  - USB Power delivery, up to 100 watts
  - Supports DisplayPort Alternate Mode

USB Type-C will be the only interface you will need

- *High speed, secure data*
- *Display connection*
- *System Power*



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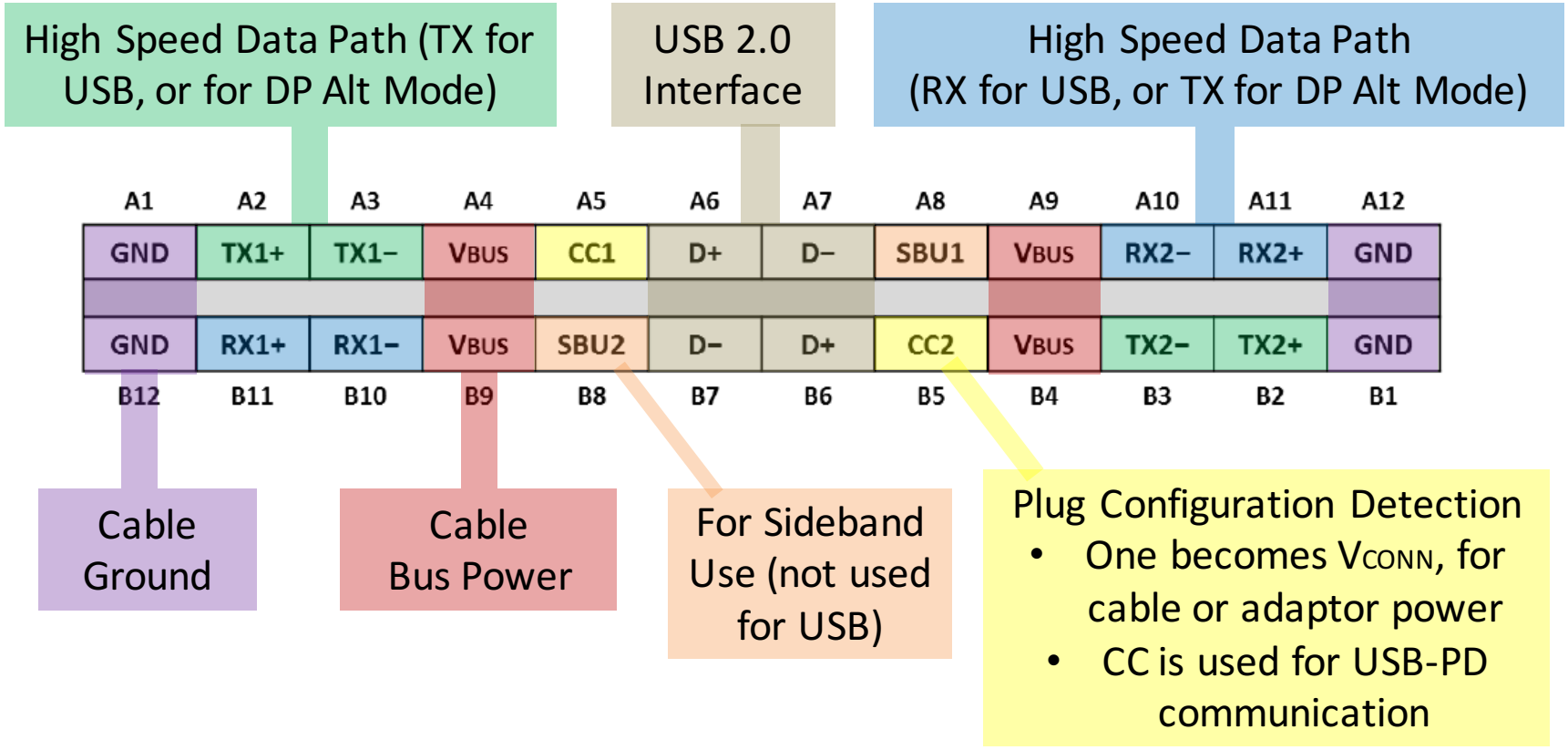
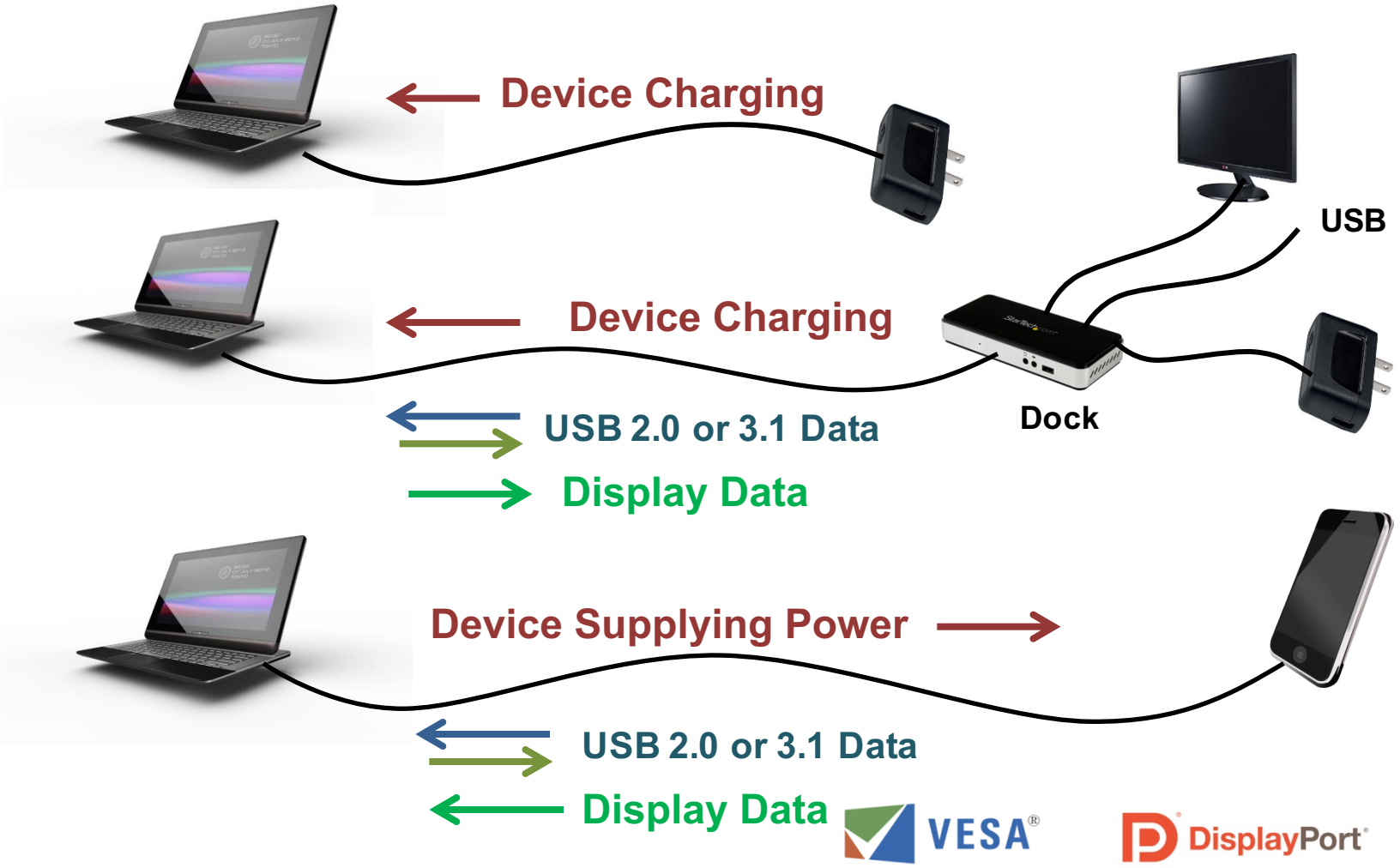
USB Type-C Receptacle Pins

Below is a diagram of the pins defined for system or device receptacle



Example USB Type-C Configurations

Either end can serve as USB Host, USB-PD Power Consumer, and DisplayPort Video Source (these services are orthogonal to each other)



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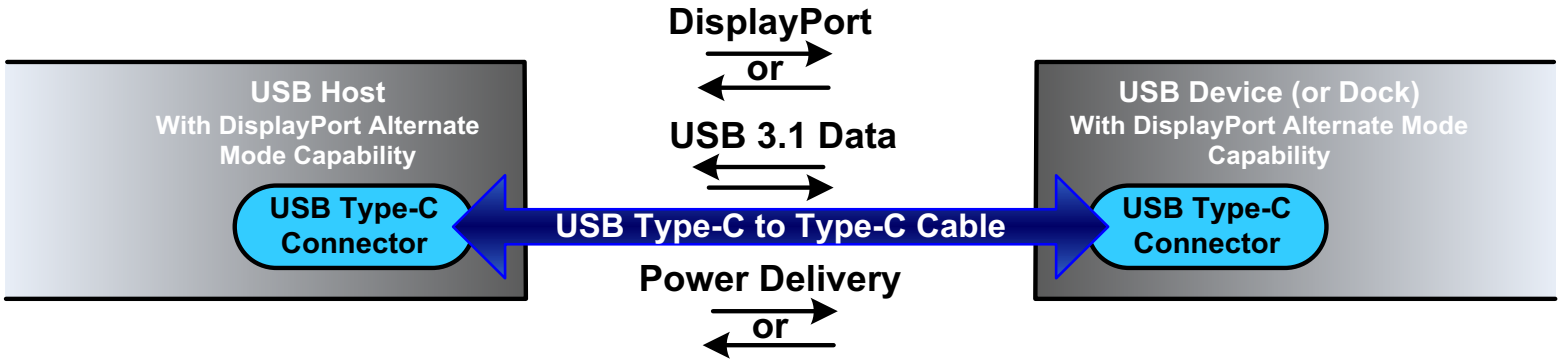
USB Type-C Connector Function Extension
DisplayPort Alternate Mode

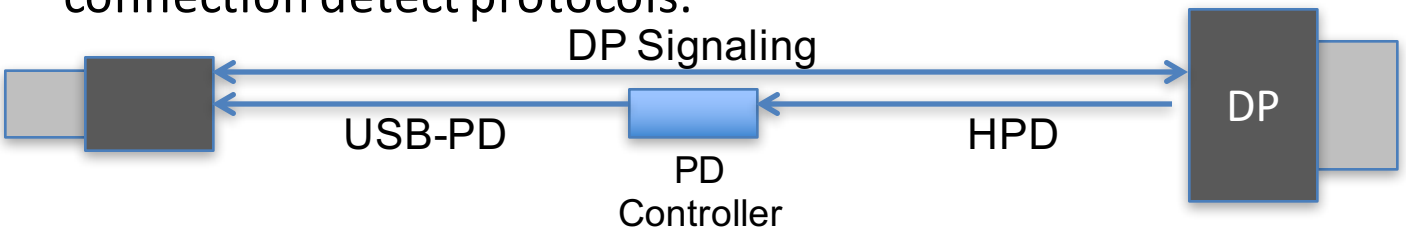


- A passive Full Feature USB Type-C to Type-C cable can carry up to four DisplayPort lanes
  - This will offer the same performance and feature capability as a standard DisplayPort connection
  - This will also allow DisplayPort data rates to increase in the future, since the USB Type-C connector has very high data rate capability
- DisplayPort can be combined with USB 3.1 operation over the same USB Type-C cable
  - Implemented with two high speed pairs for DP (using two lane DP operation), and two high speed pairs for USB (USB 3.1 only uses two high speed lanes for normal operation)
  - Useful for docking stations or hubs, or for adding docking station functionality to a display
- USB 2.0 and USB Power Delivery is available in all configurations
  - Because USB 2.0 and USB Power Delivery use dedicated wires in the USB Type-C cable, both of these services are always available, even when using all four USB Type-C high speed pairs for DisplayPort

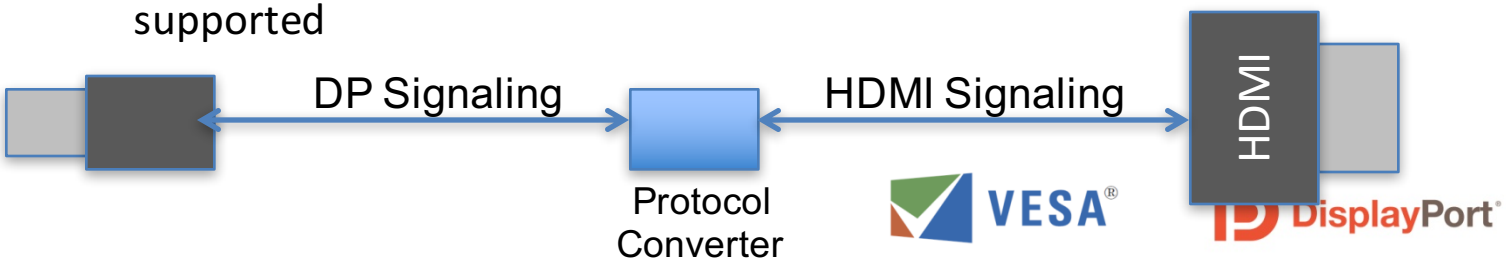
Supported Cable Types

- 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



Wide Range of Adapters Shipping Today

USB-C™ to USB A Plug

USB-C™ to USB A Receptacle

USB-C™ to DP

USB-C™ to USB-C™

USB-C™ to HDMI

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DisplayPort Alternate Mode
Compliance Test Plan

- VESA is developing the DP Alternate Mode compliance test in coordination with the USB-IF
- VESA DisplayPort over USB Type-C Compliance Test Specification (CTS) is under member review
  - Expected to publish CTS mid 2016 after member review period is completed
- 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

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DP over USB-C Product Certification

- Development phase – new products are ready to ship before compliance test programs are complete.
- Conformance testing is still important to help ensure a smooth roll-out and good user experience with early products.
- For DP Alt Mode products we created an ***early product certification plan*** to enable and promote certified products.
- Certification testing includes significant number of test requirements for USB 3.1 and USB PD certification testing coverage.
- Allion and GRL are authorized and performing certification for early DP Alt Mode products today. This will expand to all ATCs and Self Testers when the DP Alt Mode CTS and MOIs are published.

DP over USB-C Product Example Certification Tests

USB Type-C Docks shall perform the following tests:

Test Item	Test Name	Description	Requirement	Pass/Fail	Comments
6.3 #1	DP PHY TX	DP PHY TX tests up to maximum supported data rate on all DP DFPs	Pass DP TX tests		
6.3 #2	USB 3.1 Tests	USB 3.1 Electrical, Crosstalk, Functional, Link and Interop	Pass if supported		
6.3 #3	PD/USB Power	USB PD Power test requirements	All PDOs		
6.3 #4	Sink Tests	RX JTOL tests for four lanes up to Max supported rate	Pass JTOL tests in section 3.2 of DP Alt Mode CTS		Normal orientation
6.3 #5	USB-PD Protocol	Verify compliance with USB-PD protocol test requirements	Pass USB PD Protocol Testing		Normal orientation
6.3 #6	USB-PD PHY	Verify compliance to USB-PD PHY specification requirements	Pass USB PD PHY Testing		CC1 and CC2
6.3 #7	Display Interop	Using a reference DP Alt Mode source (supporting 4xHBR2) verify that a all external display connection display functions correctly at the required resolutions	Pass interoperabilty testing		Normal and Inverted orientation
6.3 #8	Vconn and Vbus	Dock tests for proper implementation of Vconn and Vbus rules	Pass Vbus and Vconn tests		Normal and Inverted orientation
6.3 #9	USB Billboard	Test compliance of USB Billboard functionality and PHY testing	Pass USB Billboard tests		Normal orientation
6.3 #10	Aux and HPD tests	USB Type-C Dock must perform all AUX and HPD tests in section 9, upstream and downstream facing ports.	Pass AUX and HPD tests		Normal orientation

Table 6-4: USB Type-C Dock test requirements

DP over USB-C Product USB Certification Tests

- USB compliance tests are conducted to achieve certification of DP Alt Mode products to ensure that functionally the USB features of those products provides a good user experience.
- Devices that support USB functionality shall conduct the USB tests included in the compliance test summary tables for each product category.
- Completing USB-IF certification testing and receiving USB-IF TID will be sufficient to show that those tests have been completed and pass.

DisplayPort Alt Mode over USB-C Early Product Certification Program Results

- Nearly a dozen tablets, laptops and monitors have been certified through the pilot phase of the early certification program
  - Intel (Skylake reference design)
  - Dell, HP tablets and laptops
  - LG and Asus displays
  - StarTech dock
- Several dozen more certified products are expected to be available by the end of the year

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Top DP Alt Mode Compliance Test Issues

- USB Billboard
  - Test Setup hard to obtain. Test sw is still under development
  - All DP Alt Mode sinks and dual role sources required to support USB Billboard
- USB PD Protocol failures
  - Use certified USB PD controllers and passing fw
- 2xDP/2xUSB 3.1 configuration testing
  - Cross talk between USB 3.1 lines and DP lines can degrade the link
- USB Type-C to DP Plug adapter reversibility
  - USB Type-C to DP plug adapters must work connected in both directions

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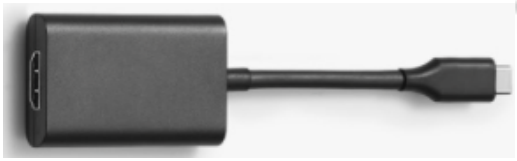
USB Billboard Test setup

- AsMedia USB-C xHCI Host Installed in available PCIe Slot
  - AT1027, Rev3.10
  - No Alt Mode
  - USB-C connector
- Windows 8.1/10 PC
- USB3CV Tool from USBIF



USB-C DP Alt Mode DUT

USB3CV Tool

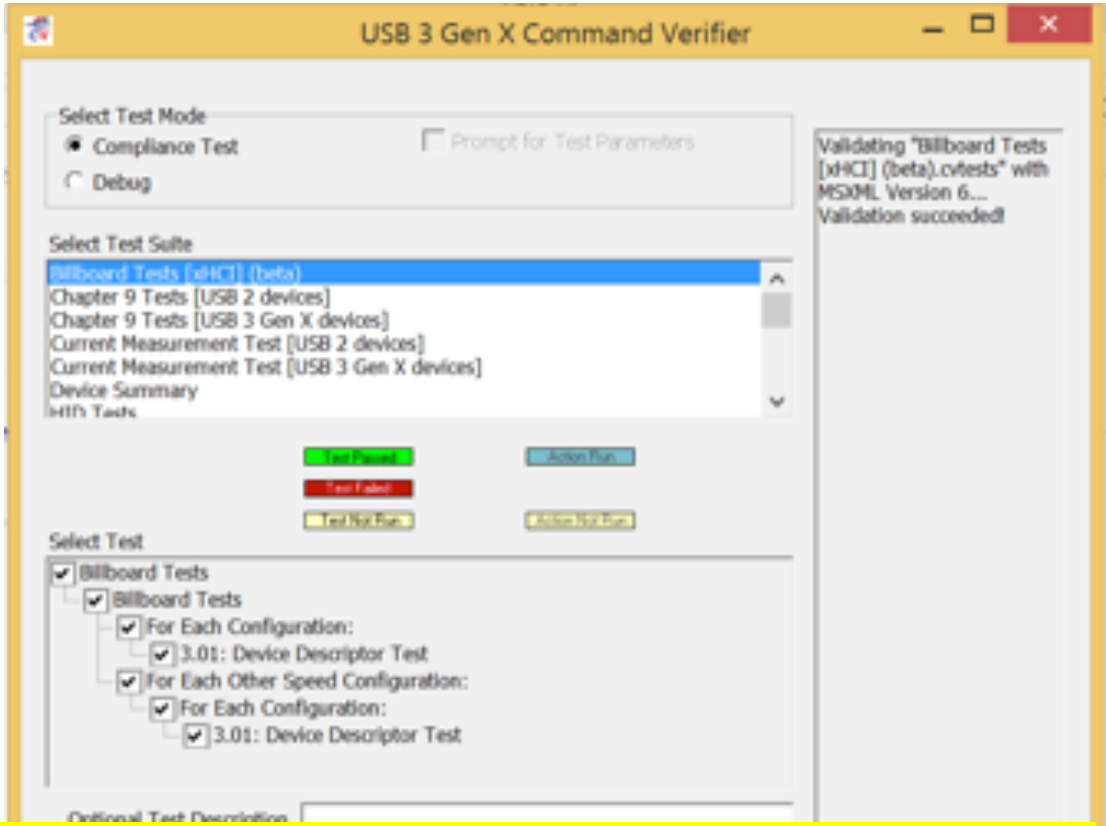
The USB3CV tool Ver. 2.1.0.0 (March 28, 2016) is available here. Download USB3CV for 32-bit Windows or USB3CV_x64 for 64-bit Windows. **In order to use USB3CV, User Account Control (UAC) must be turned off**. After turning off UAC, the system must be rebooted. If you are running on 64-bit Windows, you must install the 64-bit CV. If you have any questions, please contact ssusbcompliance@usb.org.
NOTE: The USB3CV tool is supported on Windows 7 and above.

USB Billboard Test

Issues with Billboard

- USB-C XHCI host not yet commercially available
- CTS and Test SW not complete
- Products don't update to released/passing fw versions

USBCV from USB-IF web site



Call to Action: VESA will consider sponsoring a build of the AT1027 XHCI host card With sufficient pre-orders. Contact VESA if interested.

DP Alt Mode Certification Policies

- USB Type-C to HDMI protocol converters
  - DP Alt Mode spec states they must support HDMI 2.0 among other requirements
  - These requirements can be waived until 2018 for certification
- USB PD controller certification
  - Prior to submission of product for DP Alt mode over USB Type-C certification all products must have gotten the USB PD controller used certified by USB-IF.

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- Q&A + Demos

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Summary

- DP 1.4 provides over 50% increase in performance among other improvements
- DisplayPort over USB-C is a game changer for small form factor and portable products
- **DP Alt Mode CTS will be available in early Q3 of 2016**
- Testing and certification of DP Alt Mode products is comprehensive and underway
- Next VESA PlugTest event scheduled in September 2016 in Burlingame CA

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QUESTIONS?

DEMO STATION OVERVIEW

Demos

- Keysight - DP Alt Mode over USB-C Transmitter test demo
- Tektronix – HBR3 transmitter test
- Allion – HBR3 Jitter tolerance demo
- GRL- USB PD compliance testing
- Luxshare – ICT USB-C test fixtures

Thank you!

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