VESA DisplayPort Alternate Mode on USB-C Technical Overview

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Agenda
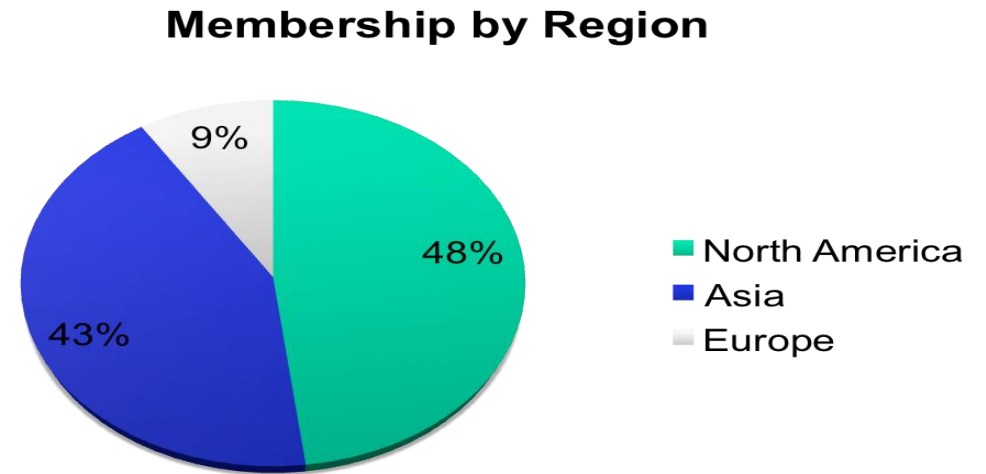
- Introduction

- DisplayPort Technology Roadmap

- DisplayPort Alternate Mode on USB-C Technical Overview

- Compliance

- Demo

- Summary

USB Type-C^{TM} and USB-C^{TM} are trademarks of USB Implementers Forum

About VESA

Membership by Region

VESA is the **Video Electronics Standards Association**

Global industry alliance with **more than 230 member companies**

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

Facilitates display related standards development, publication and compliance testing, as well as promotion and marketing

Develops Open standards, contribution is open to all companies at all stages of development

Display Trends and DisplayPort Roadmap
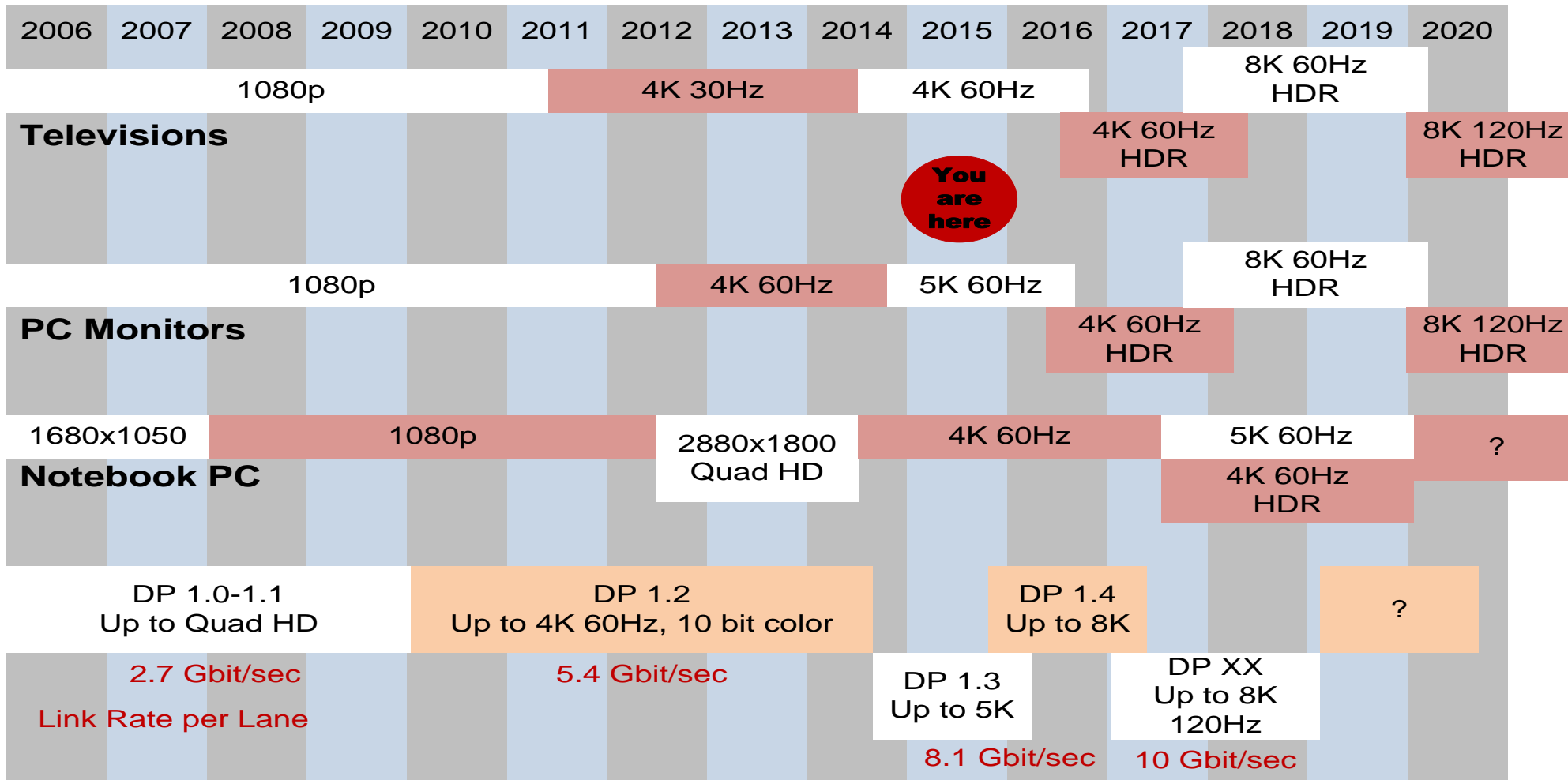
DisplayPort Specification Summary

- The VESA DisplayPort Standard, Version 1.3, was released on Sept 15, 2014

  - Replaces DisplayPort Version 1.2a for new designs

- Backward compatible, offers new optional features

- New Silicon supporting HBR3 is under development

- DisplayPort version 1.4 is under development

  - Adds DSC, Audio extensions, improved MST functionality, Adaptive Sync

  - 8K@120Hz, HDR 30bpp, 4:2:0

DP 1.3 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	HBR3	8.1 Gbps	5K x 3K	8K x 4K

Total useable data transfer rate for DP 1.3 = 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

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 1.3 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

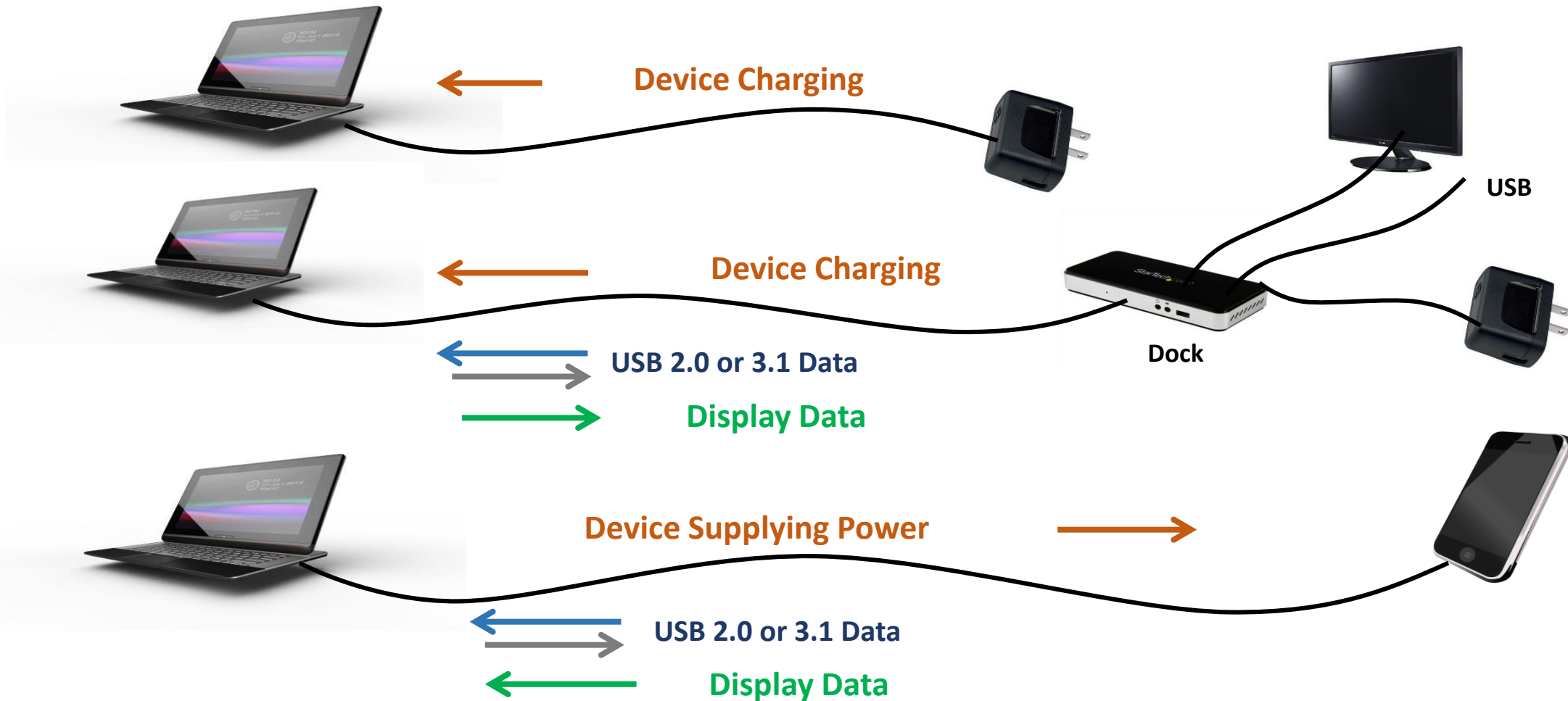- Data scrambling and fixed link rates simplify EMI and RFI mitigation

DisplayPort Alternate Mode on USB-C Overview and Certification

VESA 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

▪ Alternate Mode functional extension of the USB-C interface

▪ Developed in liaison with the USB 3.0 Promoter Group

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)

Device Charging

Device Charging

USB 2.0 or 3.1 Data

Display Data

USB

Dock

Device Supplying Power

USB 2.0 or 3.1 Data

Display Data

USB-C with DP Alt Mode Ecosystem Deployment Underway

DP Alt Mode Products

Apple Macbook

HP Pro Tablet 608 G1

Google Chromebook Pixel

Many different adapters available

- C to DP adapters

- Type C protocol converters (HDMI, VGA, DVI) using DP Alt Mode

More are expected soon

- Major PC OEMs expected to launch new products with USB-C by the end of this year

- Thunderbolt includes USB 3 + DP Alt Mode as a compatibility mode

Microsoft Lumia 950 and 950XL

Smartphones

Wide Range of Cables/DP Alt Mode Adapters Shipping Today

Standard USB-C to USB-C Cable

USB-C to VGA

USB-C to DP

USB-C to DVI

USB-C to HDMI

These adapters enable the use of the vast install base of legacy displays for the increasing numbers of systems that support DisplayPort Alternate Mode over USB-C.
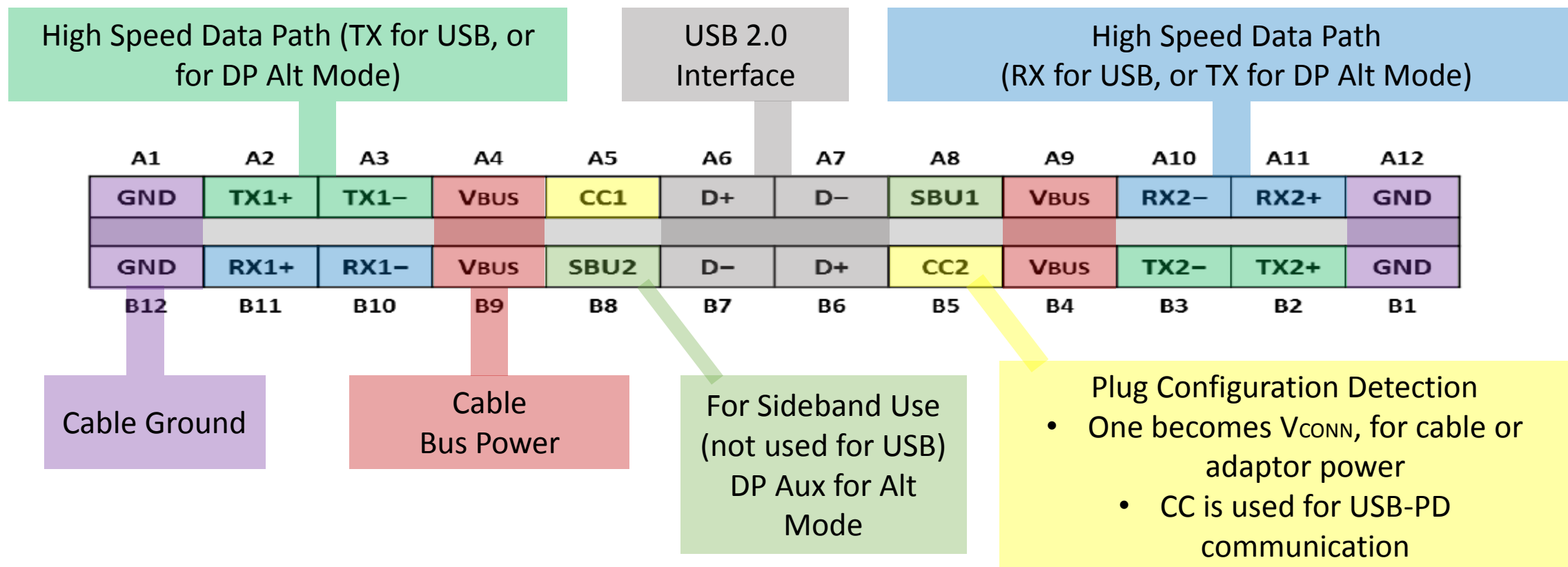
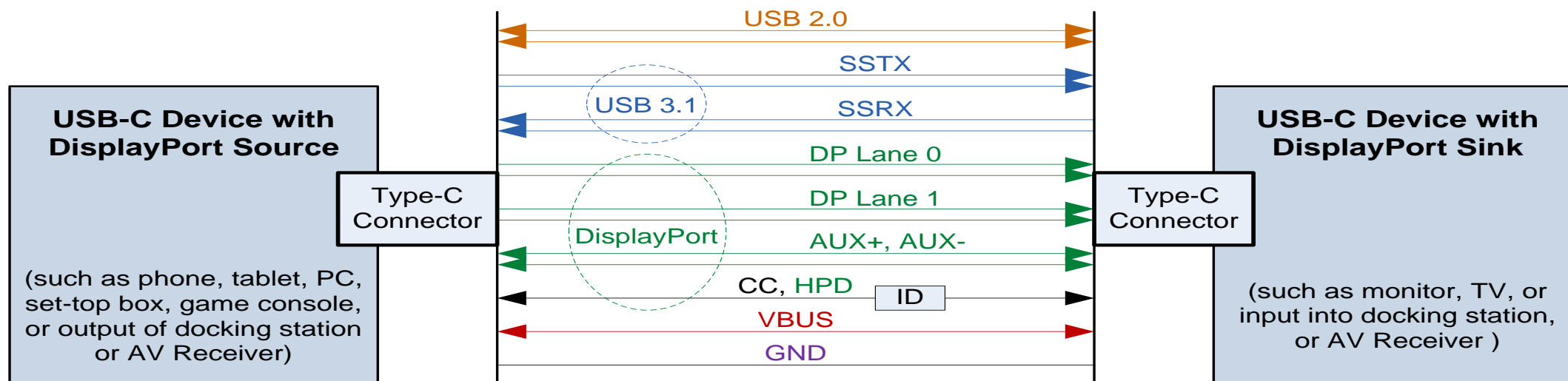# USB-C Connector Function Extension
DisplayPort Alternate Mode
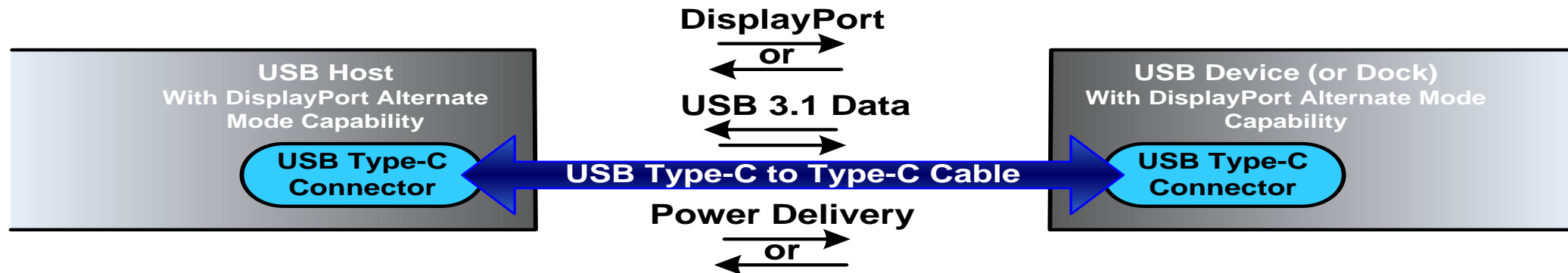
- A passive Full Feature USB Type-C to Type-C cable can carry up to four DisplayPort lanes
  - This will offer the same performance and feature capability as a standard DisplayPort connection
  - This will also allow DisplayPort data rates to increase in the future, since the USB Type-C connector has 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

USB Type-C Receptacle Pins

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

High Speed Data Path (TX for USB, or for DP Alt Mode)

USB 2.0 Interface

High Speed Data Path (RX for USB, or TX for DP Alt Mode)

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	TX1+	TX1−	VBUS	CC1	D+	D−	SBU1	VBUS	RX2−	RX2+	GND
GND	RX1+	RX1−	VBUS	SBU2	D−	D+	CC2	VBUS	TX2−	TX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

Cable Ground

Cable Bus Power

For Sideband Use (not used for USB) DP Aux for Alt Mode

Plug Configuration Detection
- One becomes V_{CONN}, for cable or adaptor power
- CC is used for USB-PD communication

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 2560 x 1600
  - DP v1.3 (future 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 redrivers 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
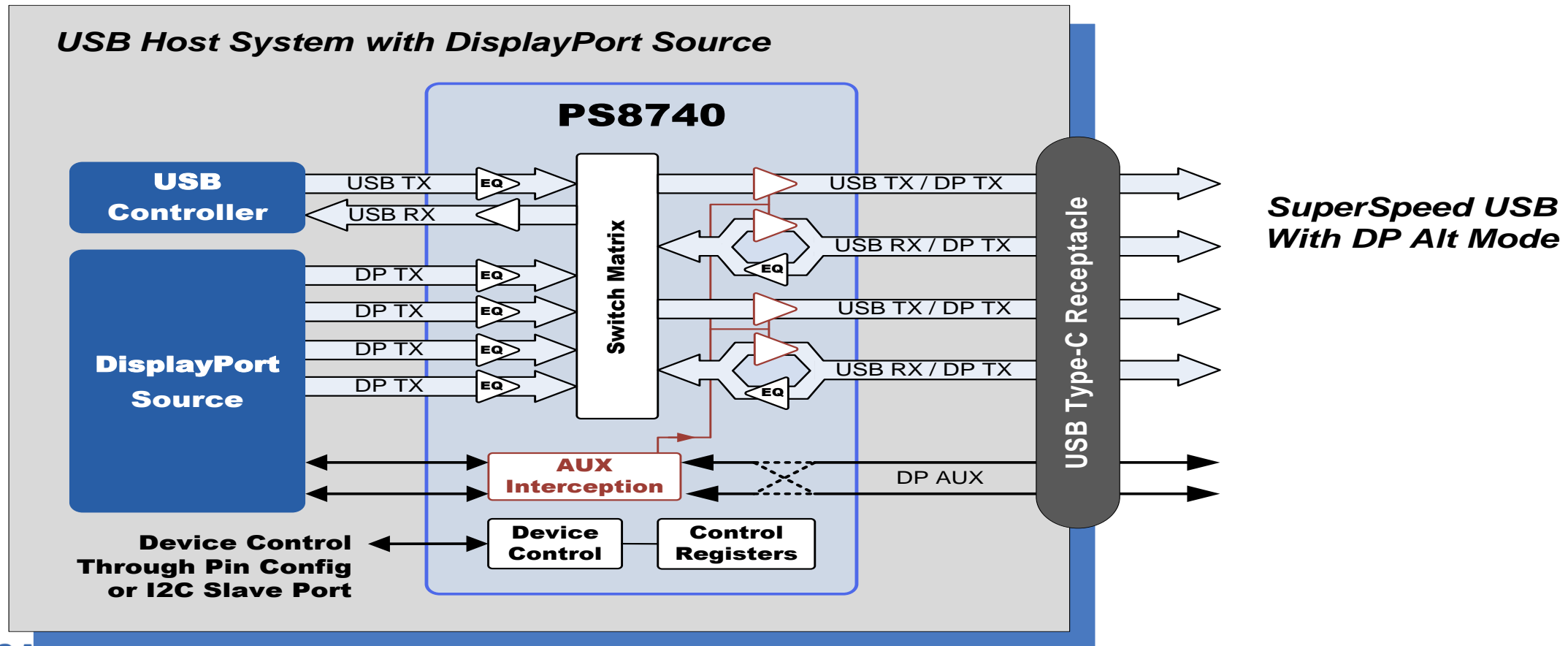
Supported cable types

- 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.

DP Signaling

USB-PD

PD Controller

HPD

DP
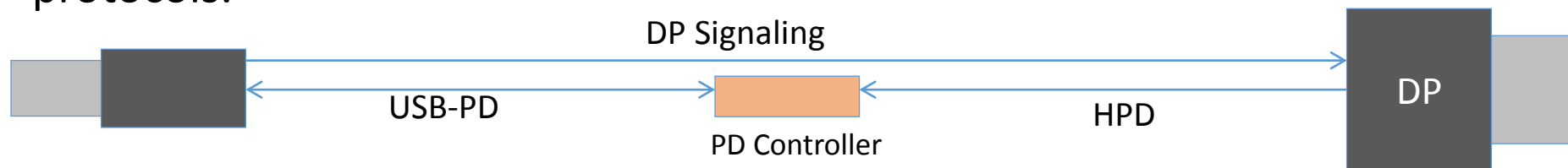
- Protocol converters must support some optional features in DP 1.3 specification
  - Protocol converters translate source DP signals to the respective protocol supported

DP Signaling

USB-PD

USB PD

Protocol Converter

HDMI Signaling

HDMI
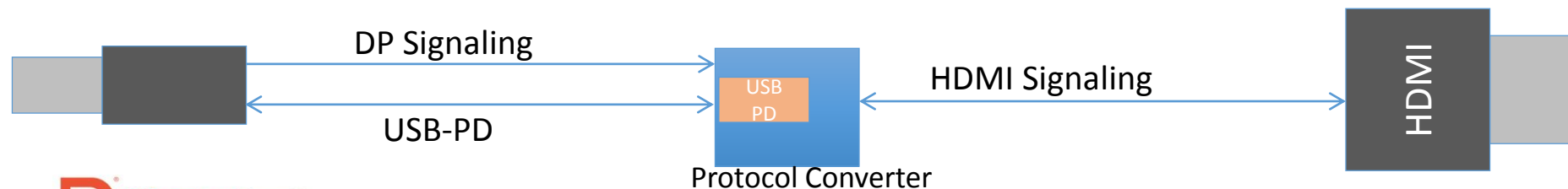
DisplayPort Over a USB Type-C to USB Type-C Full Feature Passive Cable

Please refer to the VESA DisplayPort Alt Mode on USB Type-C Standard for more information

Cable

~~SSTX1~~ DP Lane 2
~~SSRX1~~ DP Lane 3
~~SSTX2~~ DP Lane 1
~~SSRX2~~ DP Lane 0

DisplayPort Source — USB Type-C Connector — USB 2.0 — USB Type-C Connector — **DisplayPort Sink**

~~SBU1/2~~ AUX+, AUX-

CC, HPD / V_{CONN} ID

VBUS

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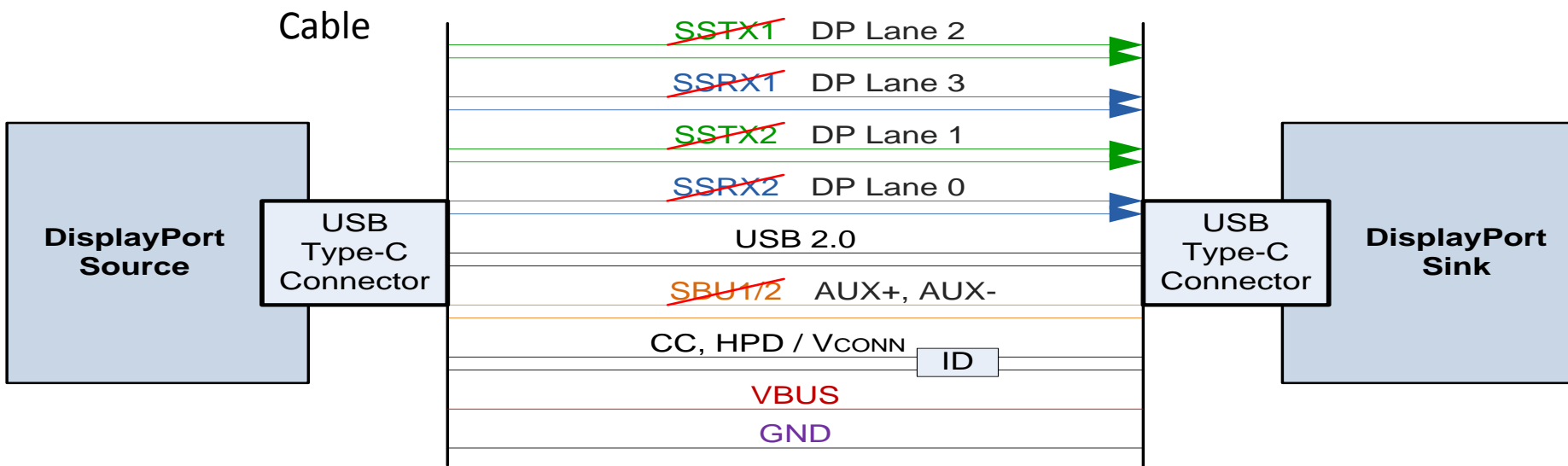
- Utilizes optional DisplayPort Alt Mode capability of USB Type-C connector
- DisplayPort can use all four high speed lanes to deliver full DisplayPort performance
- The DisplayPort AUX Channel uses the SBU pins
- The DisplayPort HPD / IRQ is transmitted over the CC pin using the USB-PC protocol
- USB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

USB Type-C to DisplayPort Adapter Cable

Cable

SSTX1	DP Lane 0
SSRX1	DP Lane 1
SSTX2	DP Lane 2
SSRX2	DP Lane 3

USB Type-C Connector

SBU1 — AUX+
SBU2 — AUX-
CC, HPD
ID — HPD Signal Conversion — HPD
V~CONN~

DisplayPort Connector

Standard DP or Mini DP Connector
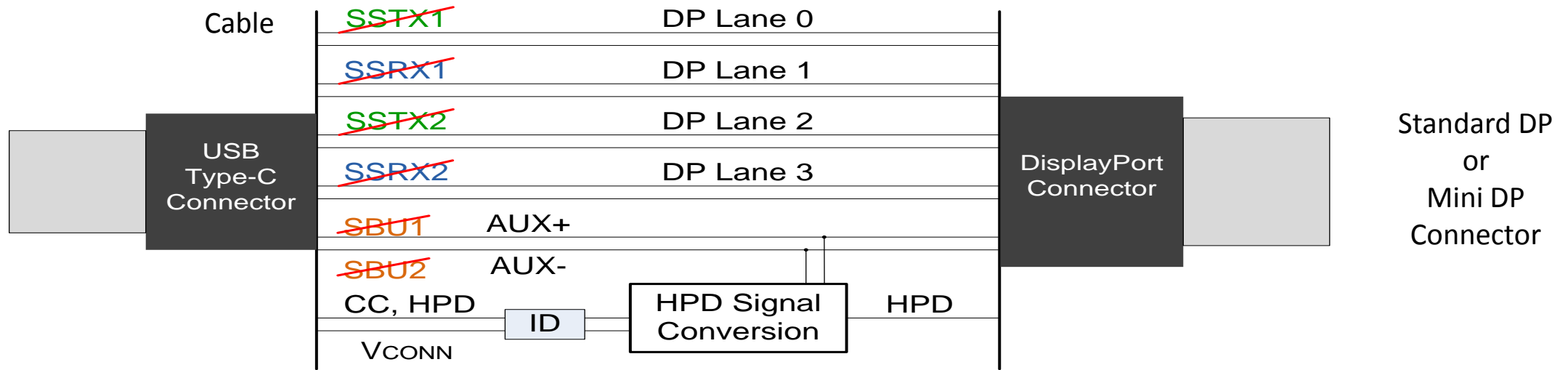
- Utilizes optional DisplayPort Alt Mode capability of USB Type-C connector
- Cable is reversible, works in either direction; four lanes of DisplayPort
- Supports legacy DisplayPort Source and Sink Devices
- Detected by USB Type-C enabled device that supports DP Alt Mode
- No support for USB or other alt modes
  - These features are not supported by legacy DisplayPort devices

USB Type-C to HDMI, DVI and VGA Adapter Cables / Cable Adapters
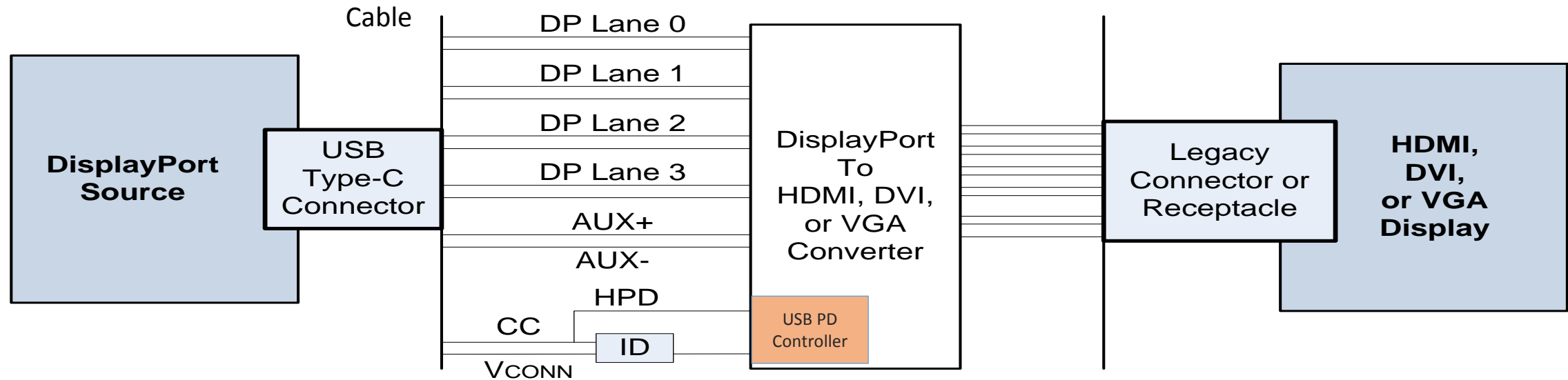
- Utilizes DisplayPort Alt Mode capability of USB Type-C connector
- Adapter Cable: USB Type-C plug on one end, legacy plug on other end
- Adapter: USB Type-C plug on one end, legacy receptacle on other end
- USB Type-C will NOT support DisplayPort Dual Mode (DP++)
- USB Type-C to HDMI Converters will support HDMI 2.0 and CEC

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

Simple Docking Configuration
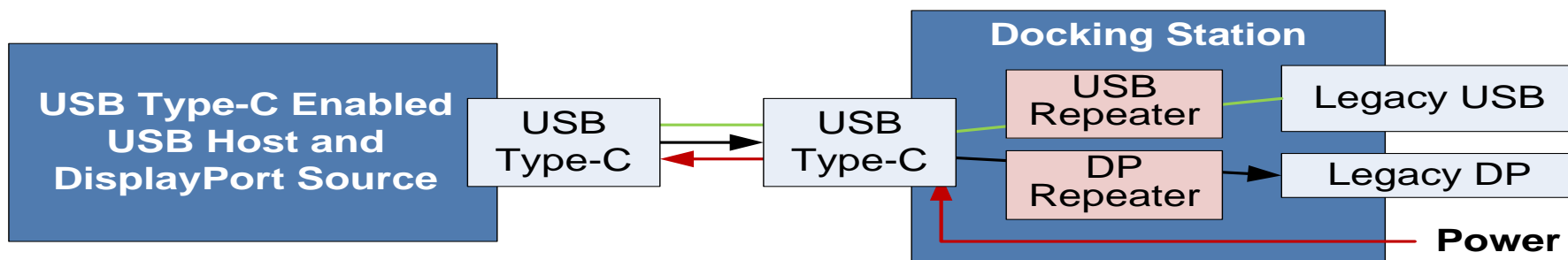
More Complex Docking Configuration
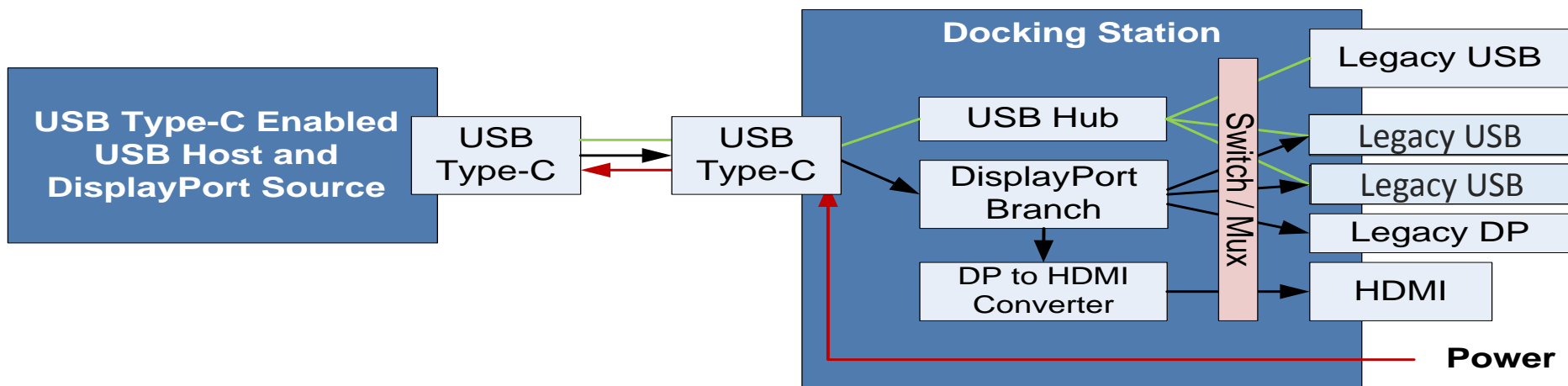
DisplayPort Alternate Mode
Compliance Test Plan

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

- Compliance test specification is under development

- 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

- Early certification of many DisplayPort Alternate Mode enabled products is in progress

Certification Test Coverage

Test plan 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 electricals
  - USB 3.1 Gen1 5G
  - USB 3.1 Gen2 10G (if supported)
  - USB 2.0 480Mb/s
- DP electricals (DP 1.2b CTS)
  - RBR
  - HBR
  - HBR2
  - Aux Channel

Certification Test Coverage (continued)

- USB 3.0 Interop testing (functional)
- USB Billboard
- Full DP certification testing using reference Adapters
  - Interoperabilty testing
    - Interop testing with a required matrix of products and adapters that are available.
    - Reference USB Type-C to DP adapters are under test now. Those that meet certification requirements will be qualified as DP Alt Mode reference adapters for certification of DP over USB-C Source and Sink products.
  - Link layer testing
  - EDID tests for sinks
  - MST testing if supported

Cable & Adapter testing

Certification testing of cables/adapters

- 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

VESA Synchronization with USB-IF Compliance Test Program

- Coordinate certification plans and timing for early products
- Avoid scheduling conflicts
- Participate in USB-IF certification and interoperability events
- VESA has been participating in USB-IOP events and workshops
- VESA participated in USBIF workshop in Taiwan last week

VESA PlugTest Events in 2015

- PlugTests have significant value to member companies. Particularly as new capabilities and products are deployed.
- VESA planned to host three PlugTests in 2015. The third event this year is in Taiwan.
- November Taiwan event introduced workshop pre-cert testing

Objectives of 2015 Plugtests
- Demonstrate and improve interoperability
  - Particularly important for new product capabilities
- Test DP 1.3 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 Milpitas
  - This Week: Taiwan November 16-19th, Westin Taipei

Logo Useage Guidlines

- 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 useage guidelines for further information
- Refer to the USB-IF Trademark License Agreement for further information

**SuperSpeed USB Trident Logo
+ DisplayPort Logo**

**SuperSpeed USB Power Delivery Trident Logo
+ DisplayPort Logo**

**SuperSpeed USB 10 Gbps Power Delivery Trident Logo
+ DisplayPort Logo**

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. Will show how this works in the demo.

- 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 1.3 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 1.1 requirements
- Compliance tests are under development to address these issues
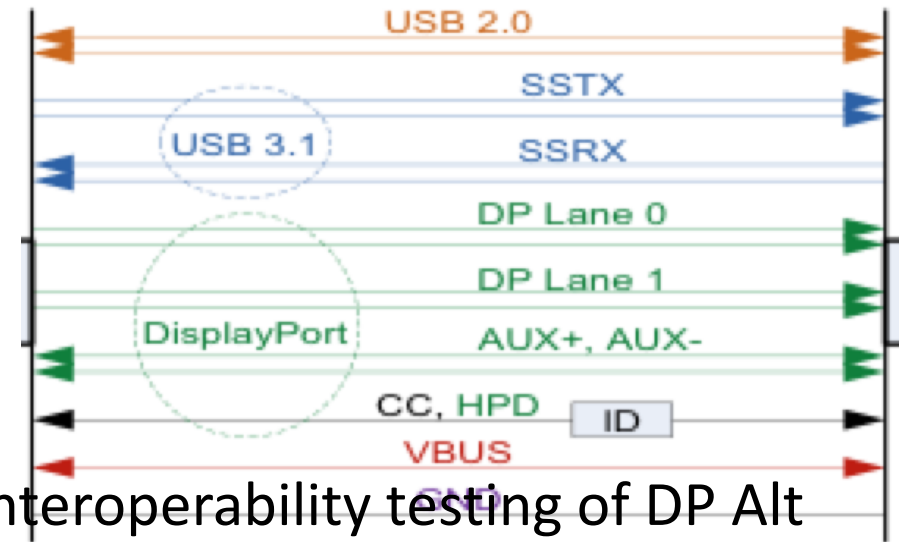
Billboard Compliance Testing

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

Billboard Compliance Testing Failures

```
ERROR        Number of interfaces = 0
FAIL      The number of interfaces of a standalone Billboard Device shall be 1.
INFO      iConfiguration = 03h
INFO      ENGLISH_US                         language string descriptor is : hoho_v1.7.575-96b74f1
INFO      Checking Interface Descriptors...
ERROR     Standalone Billboard Class device has 0 Interface Descriptors.
FAIL      A standalone Billboard class device shall have 1 Interface Descriptor.
```

```
INFO       bNumberOfAlternateModes: 1
ERROR      bPreferredAlternateMode: 1
ERROR      The preferred alternate mode must be less than the number of alternate modes (1)
FAIL       The preferred alternate mode shall be the index to a valid alternate mode.
ERROR      bcdVersion: 0.00 (0000h)
WARNING    This device supports billboard class specification 1.0. The billboard specification 1.0 has been replaced by version 1.1.
FAIL       The bcdVersion field of the Billboard Capability Descriptor shall be 110h.
INFO       VCONN Power: 0
```

Download and implement Billboard specification 1.1

DP Alt Mode PHY Testing Demo

Test Setup for DP PHY testing using DP Aux Test Automation
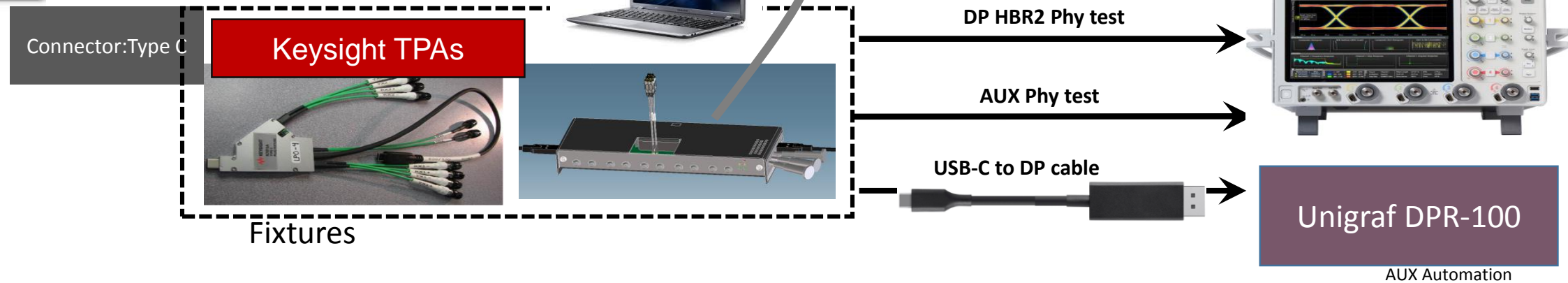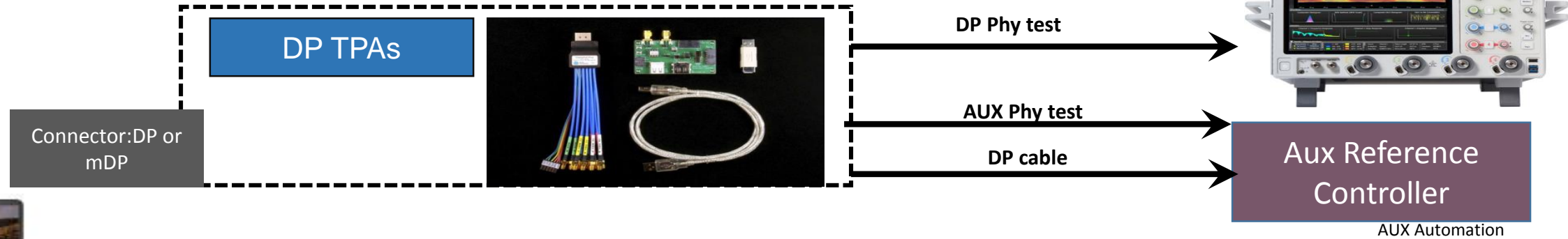
Test Setup for DP PHY testing using Link Training Test Automation

Summary

- Many USB-C devices with DP Alt Mode are in development and we should see more introduced this year.

- DP Alt Mode CTS is under development and should be released by VESA in early 2016.

- Early device certification is available from VESA in Q4 - 2015, allowing use of DP logo.

- Come visit VESA at CES this year and check out all the new DP Alt Mode over USB-C products.