

USB 3.1, USB Type-C, and Thunderbolt 3 (Part 1)

An Introduction to the Latest Interfaces



This article is intended as an introduction to the new SuperSpeed USB 10 Gbps (USB 3.1 Gen 2) interface, and the new USB Type-C connector specification, including the recently published USB Audio Device Class 3.0 specification, which standardizes audio over USB Type-C. And because, one cannot be discussed without the other, we also cover the related Thunderbolt 3 technology. First, we will explain the updated specifications fundamentals. Then, we will explore how this will affect the audio industry and important considerations for audio product developers.

By
João Martins

(Editor-in-Chief)

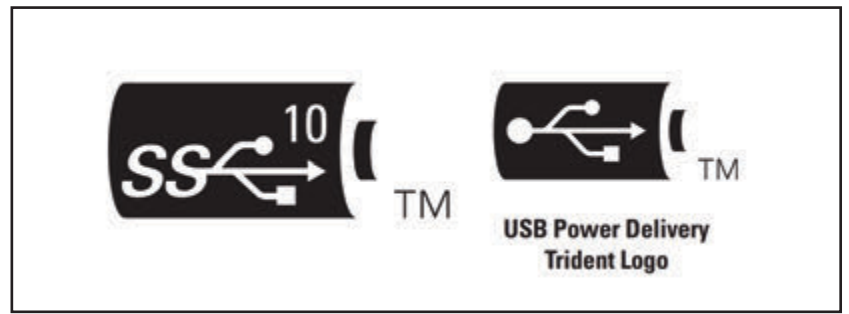
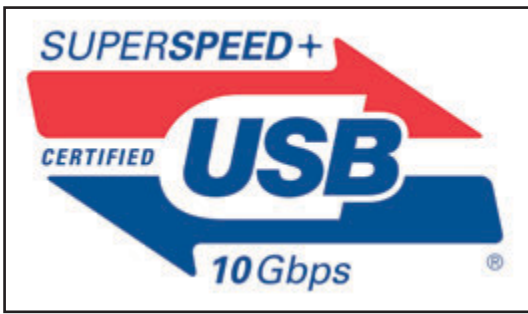
Why is the recently updated USB 3.1 specification and the new USB Type-C connector, or USB-C, associated with Thunderbolt 3? What's new with the USB Audio Device Class 3.0 specification? How can manufacturers and developers plan ahead for new designs based on those new technologies and specifications? We find the answers by questioning some of the key executives involved in the process—the USB Implementers Forum (USB-IF), the group of companies that developed the Universal Serial Bus specification, and the Thunderbolt consortium of companies, both led mainly by executives from Intel Corp.

Given the announced release schedules and the pace of new product introductions, we started the research process at the CES 2016 show in Las Vegas, NV, where we assumed it would be a key topic to address in this magazine just a

few months later. However, that did not come to fruition. Several factors might explain the reason why those “hot” technologies at CES 2016 are only now barely reaching the stores at the end of 2016. Still, before we provide more announcements on these topics, which are certain before and after CES 2017, we decided it was time to publish the available information and start with some fundamentals.

What is USB 3.1 and USB Type-C?

The new SuperSpeed USB 10 Gbps (USB 3.1 Gen 2) specification adds a 10 Gbps speed mode that uses a more efficient data encoding, over enhanced, fully backward-compatible USB connectors and cables. The specification describes the mechanical, electrical, protocol, and hub definition while maintaining compatibility with existing USB 3.0 software stacks and device class



USB 3.1 enables speeds up to 10 Gbps, supporting audio/video for USB hosts, hubs, and devices. Combined with USB Type-C, USB 3.1 and USB Power Delivery define a truly single-cable solution for audio/video, data, and power delivery, building on the existing global ecosystem of USB/IEC 62680 series of International Standards compliant devices.

The USB Trident Power Delivery logo was created to help identify the latest generation USB 3.1 connectors and might include the “10” (Gbps) indicator.

protocols as well as with existing 5 Gbps hubs and devices and USB 2.0 products.

USB Type-C, or USB-C, is a separate specification for connectors and cables. It describes a new generation of symmetrical and reversible connectors—replacing all existing previous USB connectors, including mini or micro connectors. Both sides (top and bottom) can be inserted in the port in either direction, meaning that the user no longer has to make sure a cable is inserted “right-side” up. It also can deliver up to 100 W of power and supports alternate modes, such as DisplayPort, Thunderbolt, and so forth.

friendly reversible design and enables the cable to be inserted into the devices in either orientation or direction. A connection between two Type-C devices still requires that one device is configured as a host and the other remains a device. This is determined on connection. But since USB Type-C cables are fully symmetrical, there is no host- or device-specific end of the cable.

USB 3.1 cables with the Type-C connector enable users to charge and power any USB-C enabled device, sync and transfer data at up to 10 Gbps transfer speeds. This is up to 20 times faster than USB 2.0 (480 Mbps), 12 times faster than FireWire 800, and twice as fast as USB 3.0 (5 Gbps). This is fast enough to carry full HD uncompressed video and multichannel audio.

USB Type-C connectors also define a number of new capabilities starting with USB Power Delivery, developed to provide flexible, bi-directional power capabilities by enabling faster charging and increased power levels up to 100 W. The USB Power Delivery specification defines standardized features that support the global adoption of interoperable power supplies, helping to reduce electronic waste and increase re-usability of adapters and chargers for consumer electronics.

The new symmetrical/reversible Type-C to Type-C cable assembly also provides a user-

friendly reversible design and enables the cable to be inserted into the devices in either orientation or direction. New USB Type-C alternate modes enable support for other technologies and interfaces, because the specification defines a framework for new



USB-C is the generic name being used to identify what is in fact a combination of two separate specifications: the SuperSpeed USB 10 Gbps (USB 3.1 Gen 2) interface and the new USB Type-C specification.

The mobile industry was the first one to adopt USB Type-C connectors for new generation smartphones, allowing for thinner devices.



applications with dedicated USB Type-C physical layers and controllers.

The USB-IF is also working in conjunction with other industry consortia, such as DisplayPort, Mobile High-Definition Link (MHL), and High-Definition Multimedia Interface (HDMI) to establish support in all USB Type-C hosts and devices.

MHL technology—and its latest superMHL specification—enables consumers to connect a variety of mobile and CE products to TVs and monitors and provides up to 40 W of power. With an ecosystem of more than 750 million products, MHL delivers up to 8K 120 frames per second (fps) for home-theater products and 4K 60 fps and beyond for mobile devices. It also supports advanced audio formats such as Dolby Atmos, Dolby TrueHD, DTS:X, and DTS-HD.

The MHL Consortium has already developed an MHL Alternate Mode for the USB Type-C specification. Using the MHL Alt Mode, a USB Type-C connector and cable can support the MHL 3 specification, which includes 4K video, multichannel surround-sound audio, HDCP 2.2, and is backward compatible with existing versions of the MHL specification.

Mobile devices designed with a USB Type-C

receptacle and built to support the MHL Alt Mode will be able to connect to a large ecosystem of MHL TVs, monitors, AVRs, Blu-ray disc players, projectors, set-top boxes, and automotive products using USB Type-C to HDMI Type A MHL cables. Mobile devices with USB Type-C MHL Alt Mode can also connect to HDMI legacy displays, using adapters that support MHL-to-HDMI protocol conversion.

During CES 2016, the HDMI consortium was already demonstrating the adoption of USB Type-C connectors. In September 2016, HDMI Licensing, announced the release of an HDMI Alternate Mode specification, developed for the USB Type-C specification, allowing for HDMI-enabled source devices to utilize a USB Type-C connector to directly connect to HDMI-enabled displays, and deliver native HDMI signals over a simple cable without the need for cumbersome protocol and connector adapters or dongles.

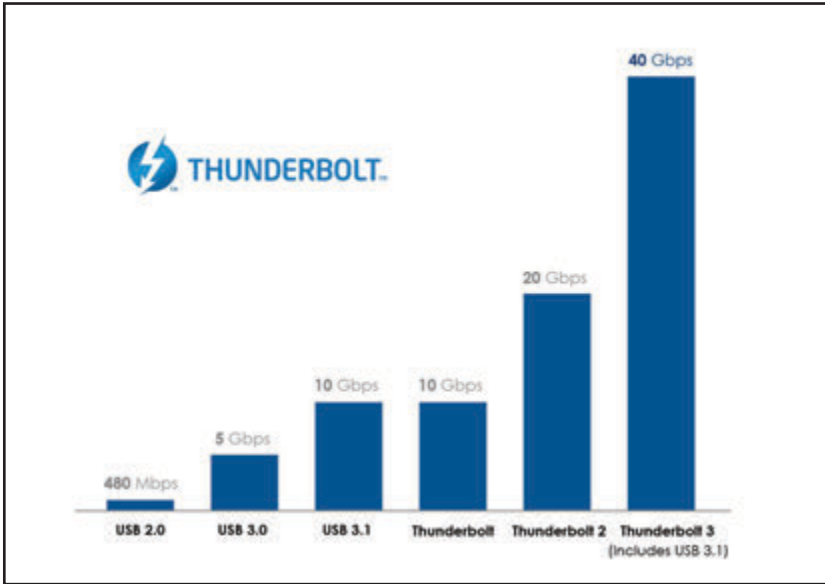
As the announcement stated, “This enables two of the most popular solutions for connectivity to come together—the small form factor, reversible, and multi-purpose USB Type-C connector being adopted by smartphones, tablets, and PC products, and HDMI, which is the leading display interface with an installed base of billions of displays.”

HDMI Alt Mode supports the full range of HDMI 1.4b features such as: resolutions up to 4K, Audio Return Channel (ARC), 3D, HDMI Ethernet Channel, and Consumer Electronic Control (CEC). The HDMI cable will utilize the USB Type-C connector on the source side and any HDMI connector on the display side.

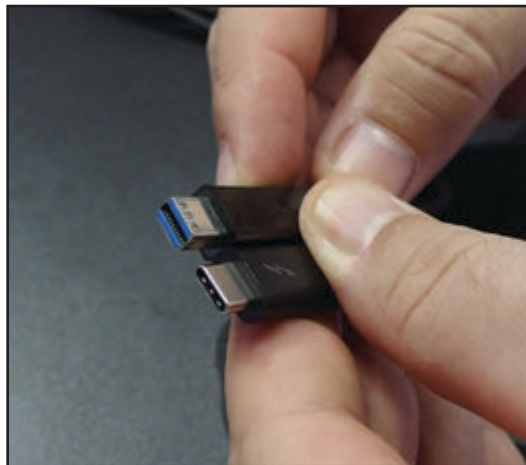
In July 2016, the International Electrotechnical Commission (IEC) formally adopted the latest USB-IF specifications for USB Type-C Cable and Connector, USB Power Delivery, and USB 3.1 (SuperSpeed USB 10 Gbps) specifications.



Thunderbolt 3 defines a superset of capabilities over USB-C connectors and cables. At 40 Gbps, Thunderbolt 3 is the fastest connection available and is bi-directional with four lanes of PCI Express Gen 3 and eight lanes of DisplayPort 1.2.



The evolution of new USB and Thunderbolt interfaces improves data transmission from 480 Mbps in the old USB 2.0 standard to 40 Gbps in the new Thunderbolt 3 technology.



The Thunderbolt original mini-DisplayPort connector is compared with the new Type-C connector with a Thunderbolt symbol.

What Is Thunderbolt 3?

In 2015, Intel unveiled Thunderbolt 3, updating the previous Thunderbolt specifications, developed in collaboration with Apple. Thunderbolt 3 brought Thunderbolt to USB-C at 40 Gbps, creating one compact port that connects to Thunderbolt devices, every display, and also billions of USB devices. Thunderbolt 3 introduces support for USB devices to its original specification and replaced the original mini-DisplayPort connector being used for Thunderbolt for the USB Type-C “universal” connector.

A single Thunderbolt 3 cable provides four times the data and twice the video bandwidth of SuperSpeed USB 10 Gbps (USB 3.1 Gen 2), while also supplying up to 100 W of power for system charging and up to 15 W to bus-powered devices.

The original Thunderbolt technology was a transformational high-speed, dual-protocol input/output (I/O) that provided unmatched performance with 10 Gbps bi-directional transfer speeds—updated to 20 Gbps bi-directional in 2013 with Thunderbolt 2. It provides flexibility and simplicity by supporting both data (PCIe—from which Gigabit Ethernet, FireWire, or eSATA devices are easy to interface) and video (DisplayPort—compatible with DVI, HDMI, and VGA displays via adapters) on a single cable connection that can daisy-chain up to six devices.

The original Thunderbolt specification enabled new and flexible designs and thinner form factors by providing the ability to expand the system capabilities on a single cable. The Thunderbolt 2 update in 2013 saw the technology adoption grow from a standard feature of Apple’s Mac computers, to a few PCs and motherboards, and several peripheral devices.

Still, for almost a year, nothing happened on the Thunderbolt front. PC OEMs never started shipping many of the prototypes shown, Microsoft never introduced support for Windows, and the industry started exhibiting signs that something big was in the works.

The announcement that the USB Type-C specification, approved in September 2014, would adopt a reversible connector similar to Apple’s Lightning connector, was also a clear sign that Cupertino was indeed working with Intel and the USB consortium behind the scenes. Then, Intel made the Thunderbolt 3 announcement and suddenly everything seemed to make sense.

The USB Type-C connector is small, reversible, fast, supplies power, and enables other interfaces, in addition to USB, to run on it, maximizing its potential.

In “Thunderbolt mode,” a single cable supports

A Sampling of the Many Silicon Manufacturers and Development Platforms Consulted for This Article

- Cadence | cadence.com
- Cypress Semiconductor | www.cypress.com
- Lattice Semiconductor | www.latticesemi.com
- Microchip | www.microchip.com
- NXP | www.nxp.com
- Parade Technologies | www.paradetech.com
- Qualcomm | www.qualcomm.com
- Qualtek Electronics | www.qualtekusa.com
- Silicon Labs | www.silabs.com
- STMicroelectronics | www.st.com
- StreamUnlimited | streamunlimited.com
- Synopsys | www.synopsys.com/home.aspx
- Texas Instruments | www.ti.com
- XMOX | www.xmos.com

two 4K displays or displays with 5K and more, single-cable docks with charging, external graphics with four lanes of PCI Express Gen 3, and built-in 10 Gigabit Ethernet (GbE) networking. Thunderbolt 3 supports up to eight lanes of DisplayPort 1.2 (HBR2 and MST) and also provides a peer-to-peer connection at 10 GbE speeds to quickly transfer files between computers, perform PC migrations, or set up small work groups with shared storage. Solutions and products previously built to Thunderbolt and Thunderbolt 2 specifications will work with Thunderbolt 3 via adapters.

According to the official Intel/Thunderbolt website, more than 60 PC designs in different form factors were introduced from leading vendors in 2016 or are scheduled to be in the market in early 2017. Products scheduled to be released in 2017 also include PC docks, high-speed storage solutions, external graphics devices, and more.

The Universal Connector: Dream or Nightmare?

Considering that USB-C connectors are being quickly adopted on new-generation smartphones (not necessarily with updated USB 3.1 specs), Microsoft supports USB 3.1/USB-C on Windows 10 and the fact that new Windows 10 machines are also supporting Thunderbolt even if in proprietary alternate implementations (not supported directly by Microsoft), the implications for all industries are huge, with video projectors to cameras to audio interfaces standardizing to a single connector—with support for multiple interfaces.

Initial products with Thunderbolt 3, mainly storage devices, started to ship in 2016. Unfortunately, Apple delayed the introduction of its Mac computers with the new interface while waiting for the availability of a new generation of Intel processors with significant improvements. The result—as it turns out to be the norm in past years—was that the entire PC industry also delayed the introduction of new machines with Thunderbolt 3 during most of 2016. And even the few models that were introduced have not implemented it to the full Thunderbolt 3 specification.

As Greg LaPorte, vice president of sales and marketing for Sonnet Technologies—a provider of Thunderbolt-to-PCIe card expansion systems and storage systems—explained, new computers already introduced in 2016 did not fully support all the features of Thunderbolt 3.

According to LaPorte, some computer models have not shipped with support for four times lanes of PCIe Gen 3, but only provide two times lanes to Thunderbolt, have only support for one



This is a Windows Dell laptop with support for Thunderbolt 3 as demonstrated at CES 2016.

stream of DisplayPort 1.2 instead of two (which means supporting only one 4K display and not 5K). Even worse, instead of providing 15 W of power to Thunderbolt 3, they only provided 7.5 W, which means that not all Thunderbolt 3 bus-powered devices will be supported by that computer. “I am hopeful that the upcoming crop of computers will have fewer models lacking these features,” LaPorte told us.

The reason why PC makers are waiting has to do with the conviction by many that even Apple will implement only USB 3.1 in some machines, such as its MacBook series, making Thunderbolt 3 only available for the Mac Pro, iMac, and the MacBook Pro range.

From the Windows camp, apart from workstation-class applications, there is a conviction by many vendors that 10 Gbps and USB 3.1 would be sufficient for generic PCs. Maybe the need to



HDMI 2.0a is now available over USB-C. Parade Technologies also implemented DisplayPort Alt Mode over USB Type-C to HDMI protocol converters.



Video Electronics Standards Association's (VESA) DisplayPort digital display interface now also runs over USB-C.

support 4K displays and gaming applications could be the incentive needed for those companies to fully embrace Thunderbolt 3, but only if Microsoft decides to introduce native support.

This uncertainty is likely to remain within the computer industry, but the mobile industry is not waiting. New smartphones will ship with USB Type-C connectors and compatible new-generation chargers. From Apple, as we've seen with the iPhone 7, there is a Lightning connector for everything and the new flagship phone now ships only with Lightning-


equipped earphones. There is no Lightning connector even on Mac computers, so this means that either users go back to their original headphones with the old analog jack when they use a computer, or they need a Lightning to USB Type-C converter to listen to music on their MacBooks. This means that the market for adapters will be booming, but more worrisome will be the fact that not all cables will be the same, even if they seem to have the right connectors.

For consumers, this will mean that they will have to learn to actually recognize the tiny symbols on ports and cable connectors, to distinguish if it is a Thunderbolt connection, a USB-C, or an USB Type-C port used for some of the Alternate Modes. And this could become even more confusing with devices that supply power and charge other devices, not to mention that there are great limitations on the length of USB-C cables (1 m or 3.3' on USB 3.1 Type-C Gen 2) if you expect to supply bus-power on a cable.

Limitations in length are less with Thunderbolt cables, but they also exist—up to 2 m if providing power. A 2 m Thunderbolt 3 cable can also be used with USB 3.0 and 3.1 devices, with data transfer speeds of up to 5 Gbps. Great lengths, from 5 m up to 60 m are possible with Corning's optical Thunderbolt cables but obviously those cables don't supply power.

The USB-IF is already working on certification programs for cables and chargers, and it recently published a Certified USB Charger Compliance and Logo Program, based upon the USB Type-C and USB Power Delivery specifications. Certified USB Chargers will now display a new logo identifying the power capability in watts. That program was announced in August 2016.

The more we learn about it, the more complicated the idea of having a single "universal" connector type seems to be than initially envisaged—since the same connector can be used for many different purposes and is able to support Alternate modes, something which is not immediately obvious to the user. Also, because people tend to store all the cables and power adapters/chargers that came with their smartphones, computers, and other devices in the same drawer—and when all those cables use the same connector—users will pick the first one they find and the one with the desired length. Those users might be disappointed when they plug it in and things don't work... or worse.

As recently published stories have shown already, the market is already being flooded with USB Type-A to USB Type-C cables that are not implemented according to the specifications and have the wrong resistors, causing damage on laptops. And, we are just getting started. 

Resources

M. Christiansen, "Implementing USB Type-C in High-Speed USB Products" Application Note: USB IP, Synopsys, www.synopsys.com/Company/Publications/DWTB/Pages/dwtb-usb-type-c-2015q3.aspx.

——, "Converting Existing USB Designs to Support USB Type-C Connections" Application Note: USB 2.0 PHY and Type-C connectors (available through Solvnet), www.synopsys.com/Company/Publications/DWTB/Pages/dwtb-convert-usb-design-type-c-2015q1.aspx.

S. Haskell, T. Nguyen, F. Yan, and A. Salazar, "Challenges of USB 3.1 IP Certification," www.synopsys.com/COMPANY/PUBLICATIONS/DWTB/Pages/dwtb-challenges-usb-certification-2016q2.aspx.

High-Definition Multimedia Interface (HDMI) | www.hdmi.org

Mobile High-Definition Link (MHL) | www.mhltech.org

Sonnet Technologies | www.sonnettech.com

Thunderbolt Technology Community | thunderbolttechnology.net

USB Implementers Forum (USB-IF) | www.usb.org.

Sorting Out USB Type-C, Thunderbolt 3, and USB 3.1

Greg LaPorte is vice president of sales and marketing for Sonnet Technologies, a provider of Thunderbolt-to-PCIe card expansion systems, pro media readers, RAID storage systems and storage, network, and other interface cards for professional users in the audio, video, and broadcast industries. He kindly answered our questions on these technologies.

audioXpress: What are the most common misconceptions about USB Type-C?

Greg LaPorte: There are many—including the assertion that USB Type-C and USB 3.1 are the same thing. In reality, a Type-C connector supports many different protocols in addition to USB 3.1, including USB 3.0, Thunderbolt 3, and many types of video protocols such as HDMI.

I have also heard that Type-C is replacing Thunderbolt, which is also not true. The next-generation Thunderbolt 3 interface has adopted the Type-C connector and incorporated the ability to accept USB 3.1 and USB 3.0 devices, as well as video protocols.

audioXpress: What are the benefits of USB Type-C/USB 3.1, and how is it being received in the market? Will it eventually replace all other USB formats?

Greg: At a purely physical level, USB Type-C is a more convenient connector because it has no up or down orientation and can be plugged in either way without flipping. It's also very thin, allowing notebook computers, tablets, and even cell phones to trim down even more. The high-speed USB 3.1 Gen 2 protocol can transfer data at 10 Gb/sec, as fast as the original Thunderbolt protocol and double the 5Gb/sec of USB 3.1 Gen 1 and USB 3.0. However, Thunderbolt 3 is now even faster, clocking in at an amazing 40 Gb/sec.

USB 3.1 has a more robust power delivery profile, allowing up to 100 W of upstream power for charging host computers from capable devices. You can push power up from a device to the host through the same port that the device is using to communicate with the computer. There are complex power delivery specifications for managing that, but the upshot is a lot more flexibility and convenience. A docking station is a good example. With one cable to connect multiple peripherals (attached to the dock) and provide power to the computer, you can keep your laptop's power adapter in your travel bag.

audioXpress: What's driving the convergence of USB-C and Thunderbolt 3? How are they complementary?

Greg: With Thunderbolt 3 adopting the Type-C connector, it appears the handwriting is on the wall—eventually USB Type-C will become the de-facto connector. What is really exciting is Intel's strategy

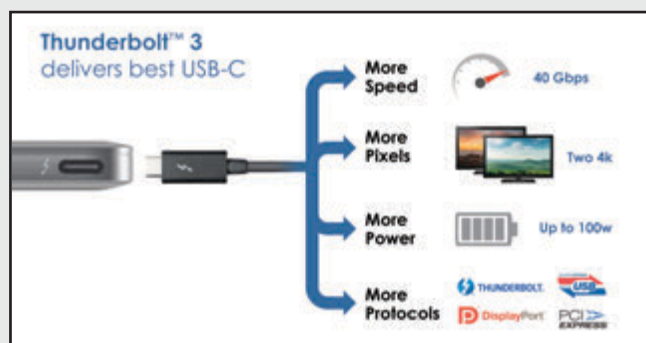


Greg LaPorte is vice president of sales and marketing for Sonnet Technologies.

to create what they're calling "the USB-C that does it all."

In addition to adopting the Type-C connector, Intel has embedded USB 3.1 Gen 2 support in its Thunderbolt 3 chips. This has paved the way for a superset universal port that can support just about everything, including all the popular video protocols (video and PCIe data over a single cable has always been one of the key features of Thunderbolt technology). In other words, with the right Type-C adapter, devices supporting any Thunderbolt version, any USB version, and (DisplayPort, DVI, HDMI and VGA) video protocol can connect to a Thunderbolt 3 port and oh, by the way, if the device supports the advanced power delivery features that I previously mentioned, Thunderbolt 3 handles that as well.

While earlier Thunderbolt versions were primarily adopted by Apple, with Thunderbolt 3 we are seeing broad adoption by Windows PC manufacturers. The first wave of these computers



The next-generation Thunderbolt 3 interface has adopted the Type-C connector and also incorporated the ability to accept USB 3.1 and USB 3.0 devices, and video protocols.



Sonnet Fusion PCIe Flash Drive SSD storage device with Thunderbolt 3 interface for Mac and Windows.

is sporting one or two Thunderbolt 3 ports plus a few legacy USB 3.0 Type-A ports. I think in time we will eventually see only Type-C USB connectors on notebooks and, if I had to bet on it, I'd put my money on Thunderbolt 3 (and its successors) becoming the de facto computer interface.

audioXpress: What advice would you give consumers to sort out the confusion?

Greg: If I were choosing a new computer today, I would definitely select one with Thunderbolt 3 over one equipped solely with USB 3.1 because it offers so much flexibility and versatility. You have access to a much greater bandwidth, and you can connect to anything and daisy chain many devices from one connection. With Thunderbolt 3 you don't have to worry about whether you can connect the device you want to use. If it has a Type-C connector, or if it will connect to an adapter with a Type-C connector, it will work.

From a device perspective, it's a different question. If the computer you're trying to connect to only has USB 3.1, you have no choice but to select a USB device. If the host has Thunderbolt 3, your options are wide open, depending on what you are expecting from the device. If the ability to support daisy chaining of multiple devices is important, select a Thunderbolt device with two Thunderbolt ports. If performance above 800 MB/sec is important, then choose one that's equipped with Thunderbolt 2—or Thunderbolt 3 if you need greater than 1,375 MB/sec. If you need to support one or two 4K displays, Thunderbolt 3 is the correct choice. If you are selecting an external storage device with one or two spinning drives or one SATA SSD, then a USB- Type C 3.1 interface will provide plenty of bandwidth and may be a good choice as it can get all the bandwidth it needs from either a USB 3.1 or Thunderbolt 3 interface.

audioXpress: What do you see as the biggest applications/greatest uses of USB-C or Thunderbolt 3 for media production?

Greg: The increased bandwidth in Thunderbolt 3 (2,750 MB/sec compared with 1,375 MB/sec for Thunderbolt 2) will be welcome in video postproduction, DIT, and broadcast markets. For example,

with our Thunderbolt 2 PCIe card expansion chassis, the Red Rocket-X, and some video I/O cards require more bandwidth than Thunderbolt 2 can deliver—but with Thunderbolt 3 there will be plenty of bandwidth to spare.

Video ingest from Thunderbolt 3 equipped media readers, such as our CFast 2.0 Pro Card Reader, will be much faster too, leading to big time savings. Another example is our currently shipping Fusion PCIe Flash Drives, the world's fastest bus-powered portable drive. The Thunderbolt 2 version transfers data at up to 1,350 MB/sec, and the Thunderbolt 3 version up to 2,100 MB/sec. We have many customers using these as scratch drives for video editing on location. An increasing number of these customers need the bandwidth of our Thunderbolt 3 edition to handle raw 4K video at higher frame rates. Then, there is the ability to support two 4K displays over a single Thunderbolt 3 chain of devices, also a big leap forward.

In the pro audio market, there are very few use cases that even come close to maxing out the bandwidth of Thunderbolt 2, so the increased speed won't be as much of a factor. However, the convenience of a single Thunderbolt 3 port that can support devices with all types of interfaces will be a real plus. Finally, Thunderbolt 3 provides the lowest latency for PCI Express audio.

audioXpress: What should customers look for when evaluating PCIe card expansion chassis and other products that rely on Thunderbolt 2 now, and Thunderbolt 3 in the future?

Greg: Core features should include reliability, ruggedness, variable-speed cooling fans, ultra-quiet operation, and easy upgradability to the next generation of Thunderbolt. Your investment in a PCIe card enclosure goes a lot further when you can migrate to Thunderbolt 3 simply by replacing a Thunderbolt board. Beyond that, it is important to select a product with a sufficient number of PCIe slots to accommodate the cards you need today as well as those you may need in the future. For example, many of our customers find it highly desirable to expand their attached storage with high-performance SSDs mounted on one of our Tempo SSD drive cards;



An example of Sonnet's expansion chassis—the Thunderbolt Echo Express III-D for up to three PCIe cards.

in other words, storage expansion that can be mounted within the same chassis as the other cards. Without the extra card slot, they would miss out on being able to add this capability.

In some cases, users need an expansion chassis that can be rack-mounted, such as our Echo Express III-R, or even a rack-mount chassis that can also securely hold the computer, such as our xMac Mini Server or xMac Pro Server. Because of the bandwidth limitations of Thunderbolt 2, some users have hesitated to put more than one high-performance card in the same Thunderbolt 2 chassis, such as a dual-port 10 Gb Ethernet card combined with a RAID storage controller card. With Thunderbolt 3, most of these concerns will disappear.

audioXpress: What is Sonnet's product strategy for USB-C? Is it in line with Apple's strategy for the Mac Pro?

Greg: While we don't have any inside knowledge of Apple's product plans, we assume they will migrate at some point to Thunderbolt 3 for next-generation Macs. For us, the bigger question is when we will see new product from Apple with Thunderbolt 3, and which Mac models will be first. But it's not just about Apple. At this point, in 2016, there are more than 60 shipping Windows computers with Thunderbolt 3, and as we roll into the 7th Generation Intel

Core processor equipped PCs (some of which have already started shipping) it is expected that more than 120 models will be equipped with Thunderbolt 3.

Uncertainty about Apple's timing aside, we have created Thunderbolt 3 versions of many of our current products and are innovating with some new product designs that will help users benefit from the advantages of Thunderbolt 3. All of our current PCIe chassis are upgradable to Thunderbolt 3, and we will soon be offering an upgrade card for that purpose, but it will be a while before Thunderbolt 2 devices are no longer needed. Intel has indicated that there were 100 million computers equipped with Thunderbolt or Thunderbolt 2 in existence at the end of 2015, so that market isn't going away anytime soon.

There are Thunderbolt adapters on the market that enable users to connect Thunderbolt and Thunderbolt 2 devices to the new Thunderbolt 3-equipped computers. The adapters will benefit those who already have Thunderbolt devices as they migrate to newer Thunderbolt 3 computers. And users purchasing their first Thunderbolt computer will have access to a large variety of ready to purchase devices. We are hopeful that in the not too distant future, there will also be bi-directional adapters that will allow new devices with Thunderbolt 3 to be used with Thunderbolt and Thunderbolt 2 equipped computers.

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The logo for Wavecor, featuring the word "wavecor" in a stylized, blue, lowercase font. The letter "v" is uniquely designed with a wave-like shape above it, and the "o" has a similar wave-like shape above it. The logo is set against a white background.

www.WAVECOR.com