

# WHITEPAPER

## COM EXPRESS REVISION 2.0

VERSION 1.0 | JULY 2010

**ABSTRACT:** *In this whitepaper, Bob follows up on his popular whitepaper on the original COM Express Specification (COM Express: The Next Generation Computer on Module Standard, June, 2005) and discusses the success and evolution of COM Express in light of the soon to be adopted COM Express Revision 2.0 specification.*

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## OVERVIEW & HISTORY OF COM EXPRESS

➔ The original COM Express specification, adopted in July, 2005, defined the mechanical, electrical and thermal requirements for a highly integrated Computer On Module (COM) mezzanine supporting a rich set of high-speed serial and I/O interfaces while preserving key legacy interface technologies to enable a smooth migration path from interface technologies at that time. It defined two mechanical form factors and five module Types that set a path for migration via the second I/O connector as interface technologies advanced and older interfaces became obsolete. The specification was a great success as demonstrated by the rich ecosystem that developed COM Express modules and the tremendous variety of applications building COM Express carriers into solutions. By far, the Type 2 Basic size module was the most commonly adopted COM Express module. More recently, with advances in System on Chip (SoC) technologies, Type 1 Basic and smaller sized modules have emerged as a second core COM Express segment. The COM Express Revision 2.0 specification builds on the success of the original COM Express specification and its surrounding ecosystem and extends that model into the future.

## COM EXPRESS REVISION 2.0 OVERVIEW & GOALS

Revision 2.0 of the COM Express specification is an evolutionary initiative to refresh the COM Express specification in support of new technologies and interfaces as well as deal with legacy interface obsolescence issues. The original module types in the COM Express Revision 1.0 specification anticipated this transition and set the stage for this evolution from legacy parallel interfaces to differential serial interfaces. The R1.0 types contained and multiplexed legacy and new interfaces on the second connector also referred to as the C/D connector. Although the large majority of COM Express designs quickly adopted the Type 2 interface, the framework of transition set forward in the original specification led to most carriers anticipating these transitions and minimizing or compartmentalizing use of these multiplexed interfaces. The R2.0 specification builds on and extends this progression while maintaining a strong view of backwards compatibility with existing designs.

As of June, 2010, the COM Express R2.0 subcommittee is in the process of final updates based on PICMG member review and will likely release the specification for final balloting by the end of the second quarter. The COM Express ecosystem is expected to quickly deliver R2.0 modules once the specification is finalized and adopted.

## TECHNOLOGY EVOLUTION—NEW INTERFACES

The primary new technology driver behind COM Express R2.0 is support of a few new interfaces, namely, Digital Display Interfaces such as DisplayPort and HDMI, as well as USB 3.0 and additional PCI Express interfaces.

### *Digital Display Interfaces*

To support the evolution of display interface technologies, COM Express R2.0 addresses two primary areas: the addition of new digital display interfaces, and the repartitioning of support for the Serial Digital Video Output (SDVO) interface. First, support has been added for up to three digital display interfaces capable of supporting High-Definition Multimedia Interface (HDMI), DisplayPort and SDVO interfaces. HDMI provides an audio/video interface that can carry TV and PC video signals, including HD video, along with an accompanying digital audio stream. DisplayPort, standardized by the Video Electronics Standards Association, provides a royalty-free interface between a computer and monitor. Unlike earlier digital display interfaces, DisplayPort is capable of driving both external displays and internal display panels, which are each important to COM Express applications. The digital display interface also supports SDVO which was previously multiplexed with the PCI Express Graphics (PEG) port on COM Express R1.0 module Types 2-5. The demultiplexing of SDVO from the PEG port was a necessary step due to the evolution of the underlying silicon technologies in support of the newer digital display interfaces. COM Express R2.0 also incorporates support for DisplayPort Dual Mode devices which support both DisplayPort and DVI and/or HDMI operating modes as defined by the VESA DisplayPort Interoperability Guidelines. Support of this VESA specification drives the display interface multiplexing in COM Express to a more standardized approach. ↘

### USB 3.0

COM Express R1.0 supported 8 USB 2.0 host ports, each of which was composed of a single differential signal pair. USB 2.0 supported transfer speeds up to 480 Megabits per second. The USB 3.0 specification expands upon USB capabilities and adds SuperSpeed capability extending transfer speeds up to 4.8 Gigabits per second. Whereas previous advances in USB signaling rates were straightforward increases on a single differential pair, USB 3.0 SuperSpeed increases are achieved via the addition of two differential pairs in addition to the legacy USB 2.0 non-SuperSpeed differential pair. To support USB 3.0 COM Express R2.0 adds support for USB 3.0 to 4 of the 8 existing USB 2.0 ports via the addition of SuperSpeed pins for the first 4 USB ports.

### PCI Express

To augment the continued success and adoption of PCI Express, the COM Express R2.0 specification also adds two additional PCI Express lanes.

## TECHNOLOGY EVOLUTION— LEGACY OBSOLESCENCE

A secondary driver behind COM Express R2.0 is to address obsolescence issues with several existing interfaces. Through its defined types, the original COM Express specification already planned for the parallel PCI bus and IDE (parallel ATA) interfaces to phase out in favor of PCI Express and Serial ATA (SATA). Since that time, technology has evolved on a few other components and key interfaces within the COM Express specification; namely, the AC'97 audio and external BIOS interfaces as well as the TV Out interface. Additionally, COM Express R2.0 recognized that the serial port, previously dismissed as an obsolete legacy interface by R1.0, has continued to endure due to its simplicity, despite the popularity of USB. Finally, the R2.0 specification also added support for a few miscellaneous I/O signals common in many mobile embedded devices. The following sections discuss each of these interfaces in further detail.

### AC'97 & High Definition Audio

COM Express Revision 1.0 supported audio via an AC'97 interface which supported the Intel Audio Codec '97 standard. Like the evolution of the digital display interfaces, the audio interface has also evolved and the result in COM Express R2.0 is upgraded audio support for a High Definition Audio (HDA) interface. The AC'97 interface and HDA interfaces share the same COM Express interface pins and are largely compatible.

### SPI

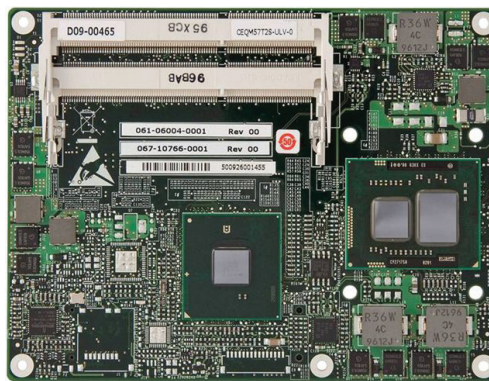
The BIOS firmware for a COM Express module normally resides on the module itself. A feature important in some applications of COM Express is the ability to boot from an alternate BIOS image located on the carrier board rather than the module. COM Express R1.0 supported this via the BIOS\_DISABLE# pin which carrier boards used to signal the module that the carrier BIOS should be used instead of the module BIOS. Over the first several generations of COM Express implementations, BIOS was typically contained in a Firmware Hub located on the Low Pin Count (LPC) interface within the module. Carriers utilizing the BIOS\_DISABLE# feature placed their alternate BIOS image in a Firmware Hub located on the LPC interface on the carrier. As technology has evolved, the Firmware Hub is rapidly approaching its end-of-life, and in its place, modern processor chipsets utilize the Serial Peripheral Interface (SPI) to interface to the FLASH device containing the BIOS image. COM Express R2.0 adds support for the SPI interface on formerly reserved pins to address obsolescence of the Firmware Hub while continuing to support the LPC interface which is still used frequently on carriers to support simple lower bandwidth devices. ↘

## NEW TECHNOLOGY

- ➔ USB 3.0
- ➔ Digital Display Interfaces

## CHANGING TECHNOLOGY

- ➔ More PCI Express
- ➔ Addition of High Definition Audio
- ➔ Need for Serial Ports
- ➔ SPI for BIOS Access
- ➔ TV Out No Longer Needed



Procelerant CEQM57XT COM Express Module

### TV Out

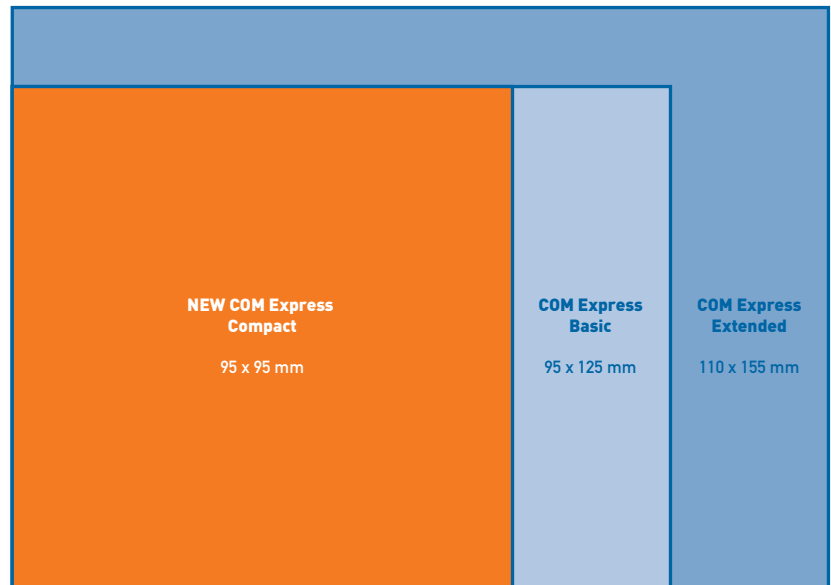
The TV Out interface was provided in COM Express Revision 1.0 to support analog video. It supported Component, Composite, and S-video signaling. With the evolution to digital display interfaces, this interface has become largely obsolete and very infrequently used and as such, support for it has been removed in R2.0 of the COM Express specification.

### Serial Ports

In hindsight, the original COM Express specification may have been a bit too aggressive in its attempts to be completely legacy free to the point of excluding a serial port interface. Despite advances such as USB, the serial port remains a key interface in embedded systems due to its simplicity, especially in regards to the software stack required to support the interface. It has been widely asserted that the most common carrier component found on the LPC interface of COM Express R1.0 carriers is a SuperIO chip primarily for the purpose of providing a serial port. The R2.0 COM Express specification corrects this by adding 2 TTL level 2-wire serial port interfaces. TTL level ports were selected for simplicity so that the carrier can either use as-is or add specific drivers to support other external serial interfaces such as RS-232, RS-422 or other serial signaling standards.

### Miscellaneous Pins

COM Express R2.0 also adds support for a few other miscellaneous I/O signals commonly found in embedded and mobile systems. For active cooling, a fan tachometer input and pulse width modulation (PWM) output have been added to enable monitoring and control of a fan subsystem without requiring an external controller. For mobile battery-powered applications, the sideband signals LID and SLEEP have been added in support of signaling external ACPI power management events. Finally, to enhance security and support systems utilizing a Trusted Platform Module, a TPM physical presence signal has also been added in R2.0 to enable a carrier to indicate physical presence of an operator for certain TPM operations.



**Figure 1.** In addition to the 95mm x 110 Basic and 110mm x 155mm Extended module sizes, the COM Express 2.0 specification introduces a new 95mm x 95mm size that will be referred to as "Compact."

## EVOLUTION—MODULE SIZES

The R1.0 specification defined 2 module sizes, Basic and Extended, which are 125x95mm and 155x110mm in size respectively. As the COM Express ecosystem developed, the majority of designs adopted the Basic module size in conjunction with mobile processors and chipsets. To a lesser extent, Extended size modules also appeared with added functionality such as dual full sized DIMMs, higher powered server class processors, or other functional extensions to the typical Basic module feature set. A recent technology trend towards smaller integrated system-on-a-chip designs and integrated chipsets (as opposed to the traditional CPU, north & south bridge design) has led to even smaller footprints and many suppliers in the COM Express ecosystem responded with what has now been defined in COM Express R2.0 as the Compact module size of 95x95mm. All 3 sizes (Compact, Basic and Extended) share a common connector footprint along with the neighboring mounting holes with each successively larger size providing additional mount points (Figure 1).

REVISION 2.0 NEW TYPES

So where do all these new interfaces and pins land in the already feature packed COM Express connectors? The COM Express R2.0 specification does a light refresh of the existing Type 1 through 5 module definitions and also defines 2 new module Types for the more extensive technology upgrades. For the existing Types 1-5, formerly reserved pins on the A/B connector have now been defined to add the SPI interface while the existing AC97 pins are updated to additionally support the High Definition Audio interface. Adding support for the newer digital display and USB SuperSpeed interfaces required a more invasive approach and R2.0 defines a new Type 6 to address these interfaces while preserving backwards compatibility as much as possible with the existing R1.0 Types. These new interfaces are defined on the C/D connector in the Type 6 module. Also added in R2.0 is a new Type 10 which is a single connector version similar to the Type 1 module in R1.0. The Type 10 definition retains backwards compatibility with the R1.0 Type 1 definition where possible, but a few interface changes were necessary in order to optimize the single connector module display interfaces for future designs. Finally, it was recognized that the original COM Express specification allocated more 12V power pins than necessary, so several of those pins have been reclaimed and used for some of the miscellaneous I/O signals that are more easily made 12V tolerant for backwards compatibility.

Type 6

Building on the success of the Type 2 connector pin out, the COM Express R2.0 specification defines a new Type 6 module. The major new interfaces (digital display interfaces, USB 3.0 SuperSpeed) are defined on the C/D connector which was already positioned in R1.0 of the specification as the multiplexing region. The USB 3.0 SuperSpeed interfaces reside in the pins formerly used for IDE in Type 2 while the digital display interfaces reside in the former PCI region of the Type 2 pin out. The PEG port defined in Types 2-5 rounds out the pins on the Type 6 C/D connector. Changes on the A/B connector in Type 6 were kept to the absolute minimum and done in backwards compatible fashion to the existing R1.0 types such that the burden of redesign falls mainly on those applications that wish to take advantage of the newer interfaces in Type 6 while those applications utilizing Type 2 that already have moved beyond use of the legacy PCI and IDE interfaces are largely unaffected. Essentially, the Type 6 module is a technology evolution of Type 2 that drops legacy PCI and IDE interfaces in favor of digital display interfaces and USB 3 SuperSpeed interfaces. (Table 1)

Type 10

The COM Express subcommittee faced a difficult decision regarding the evolution of the single connector Type 1 module. In the R1.0 standard, the Type 1 module was simply a single connector version of module Types 2-5 with an identical pin out on the A/B connector. In R2.0,

	NEW! COM E 2.0 Type 6	NEW! COM E 2.0 Type 10	COM E 2.0 Type 2
Note	No IDE, PCI	No IDE, PCI	Has IDE, PCI
Connectors	AB, CD	AB	AB, CD
PCI Express Lanes 0-5	Up to 6	Up to 4	Up to 6
PCI Express Lanes 6-15	Up to 2	None	None
PCI Express Graphics (PEG) Lanes 16-31	1	NA	1
LVDS Channel A	1	1	1
LVDS Channel B	1	NA	1
VGA	1	NA	1
Serial Ports 1-2	Up to 2	Up to 2	None
SATA/SAS	Up to 4	Up to 2	Up to 4
DDI Digital Display I/F	Up to 3	1	None
USB 3.0 Ports	Up to 4	None	None
SDIO	1	1	None
LAN port	1	1	1
PCI Bus – 32 Bit	None	None	1
IDE	None	None	1

Table 1. Module Types 6 and 10 are newly defined in the COM Express 2.0 specification to enable a legacy free design and upgrade path.

the Type 6 module was optimized around backwards compatibility on the A/B connector and the additional pins for digital display interfaces were defined on the C/D connector. The single connector version could have followed the same direction as R1.0 and simply retained the connector A/B compatibility (which is essentially what R2.0 Type 1 is defined as); however, this did not provide a migration path forward supporting a digital display interface on a single connector module. To address this, the subcommittee made the difficult decision to break backwards compatibility on the A/B connector and define a new Type 10 which adds a single digital display interface to the A/B connector. To make room for these additional pins, the existing VGA port and the second channel of the LVDS interface had to be sacrificed to provide sufficient pins. This choice was largely driven by the need to preserve backwards compatibility on A/B for existing applications and place the burden of redesign on those applications wish to take advantage of the newer digital display interfaces rather than burden those applications that are either simply evolving from R1.0 Type 1 to R2.0 Type1 or from R1.0 Type 2 towards R2.0 Type 2 or 6. To reiterate, the R2.0 Type 10 module is not a subset of the other module Types as the Type 1 module was in R1.0. ↘



## BACKWARDS COMPATIBILITY/FUTURE EVOLUTION FOR R1.0 CARRIERS

A quick survey of the many types of applications based on the COM Express R1.0 Type 2 reveals several common carrier usage scenarios that will be considered from a backwards compatibility and future evolution perspective. The first three scenarios break down based on the types of display used in the application. The next break down is based on some of the legacy interfaces used on the carrier; specifically, IDE, PCI, AC'97 and on-carrier BIOS. (Table 2)

### Display Usage Compatibility/Evolution Scenarios

A common scenario is the headless embedded system that does not rely on any external display. A second scenario is a simple display driven directly from the integrated chipset graphics controller and interfaced either via simpler VGA or LVDS flat panel interfaces. The third scenario is the higher-end displays that are typically driven via an external GPU or SDVO-based displays using the integrated GPU.

#### Headless

The headless system is simple. Since none of the display interfaces on the COM Express module are used, the carrier has no issues evolving from any of R1.0 Types 1-5 to any of the R2.0 Types.

#### VGA & LVDS

Carriers utilizing VGA and/or LVDS flat panel interfaces have a very straightforward migration path between any of the R1.0 Types and R2.0 Type 1-6 as these interfaces are unchanged between R1.0 and R2.0. For low-end single connector applications, which are typically based on Type 1, migration to R2.0 Type 10 involves changes since the Type 10 module sacrifices the VGA interface and one channel of the LVDS interface in support of a digital display interface. For applications that are ready to migrate to a digital display, carrier redesign is required to take advantage of newer display technology; applications that do not wish to evolve their display technology are likely best served by R2.0 Type 1-6 modules.

#### External PEG

Carriers that use an external GPU attached via the PCI Express Graphics x16 (PEG) interface can easily migrate between R1.0 and R2.0 regardless of whether the GPU is a device down or via an add-in GPU board. The PEG interface is supported and compatible on all of the dual connector module Types in both R1.0 & R2.0.

## COM E Revision 2.0 Changes Type 1-5

HDA Audio	Multiplexed on AC'97 pins
SPI	Added on reserved pins
SDIO Option	Optionally multiplexed on GPIO pins
I2C Multi Master Support	Capability added to existing I2C interface
TV Out	Removed
VCC_12V	1 reclaimed for TYPE10# pin

**Table 2.** COM Express 2.0 Specification changes on Module Types 1-5 have been kept at a minimum level to enable backward compatibility.

### SDVO

Carriers that utilize the internal graphics controller to drive a display connected via the SDVO interface are affected by the demultiplexing of the PEG/SDVO interface in R2.0 Type 6. These carriers further divide into two subsidiary cases—those with the SDVO devices down on the carrier and those with the SDVO devices up on an add-in board. In the case of an SDVO device down, unfortunately, due to the repartitioning of the SDVO interface and multiplexing with the digital display interfaces, a carrier redesign is needed to migrate to an R2.0 Type 6 carrier and utilize the new SDVO pin locations. Ultimately, these designs may wish to evolve to newer digital display interfaces such as DisplayPort or HDMI as part of that redesign. In the case of an SDVO device up, this was commonly implemented via the PEG/SDVO interface routing directly to a PCI Express x16 slot that supported a Media Extension Card (MEC). In this case, it may be possible to replace the SDVO MEC card with an alternate PCIe-based GPU to enable migration of the R1.0 COM Express carrier design to R2.0.

A key point in each of these display usage scenarios is that the burden of carrier redesign in migration to R2.0 falls primarily on the very applications and carriers that would most likely want to evolve to newer digital display interfaces anyway, so the R2.0 subcommittee chose appropriately as to where to break backwards compatibility and placed the burden on those designs wishing to utilize the new features. ↘

## Legacy I/O Usage Compatibility/ Evolution Scenarios

The next breakdown of COM Express R1.0 Type 2 carriers centers around the usage of various legacy interfaces; specifically, IDE, PCI, AC'97 and on-carrier BIOS. In the case of IDE and PCI, COM Express R1.0 already set the stage for the obsolescence of these interfaces with the multiplexing in Types 2-5. R2.0 builds on this base and with the definition of type 6 and 10 declares that it is time to move on from PCI and IDE for future designs. Although R2.0 compatible Type 2 modules supporting these interfaces will continue to exist, the direction for technology evolution has clearly been set.

### IDE

The most common usages of IDE on R1.0 carriers brought the interface to either a standard IDE header for a cabled connection to a drive, or the interface was brought directly to a Compact Flash socket. In conjunction with this, most carriers did the same with one or more SATA ports to future proof their design. For most of these carriers, the replacement of IDE with USB 3.0 functionality in Type 6 simply means that their IDE header is no longer functional, but most of them can simply move on and use a cabled SATA interface with newer drives (if they in fact haven't already). Very few R1.0 carrier designs are completely broken due to this migration (mainly IDE device down scenarios or those carriers that didn't also bring out SATA headers). Although they don't gain usage of USB 3.0 SuperSpeed without redesign, the existing carrier can move forward with Type 6 modules minus the IDE functionality.

### PCI

There were 3 basic usage scenarios for PCI on R1.0 Type 2 carriers. The first and simplest case is carriers that didn't implement PCI which are easily able to migrate to R2.0 Type 2 or 6 modules. The second case is carriers that brought the PCI interface to an expansion slot for an add-in board. Migrated as-is to an R2.0 Type 6 module, the carrier PCI slot becomes non-functional, but many of those carrier designs also implemented one or more PCIe slots as future proofing and may be able to evolve at the system level by migrating to newer PCI Express based add-in cards on the same carrier. The third case is carriers that implemented a PCI device down on the carrier. To migrate towards R2.0 Type 6 modules, these carriers will either require redesign to add a PCI-to-PCE Express bridge, or to migrate the device down from PCI to PCI Express.

Although the PCI interface is eliminated between Type 2 and Type 6, the foundation for migration set forth in R1.0 in conjunction with these ensuing common PCI interface usage models provides a straightforward migration path for a large portion of the R1.0 carriers.

### AC'97/HDA

The common electrical interface and pin out for these 2 types of codecs makes migration from AC'97 to HDA a fairly straightforward process. This migration has in effect largely already happened even without the R2.0 specification formalizing the definition as the current generation of I/O Controller Hubs already has migrated to HDA for the audio interfaces.

### Carrier BIOS

A small, but important, segment of COM Express carriers utilized an on-carrier LPC-attached Firmware Hub to provide BIOS for the system rather than using the on-module BIOS image. With support for the Firmware Hub rapidly approaching end-of-life, COM Express R2.0 redefined several reserved pins to provide a SPI interface and allow a carrier to provide alternate BIOS via SPI-attached FLASH. The addition of SPI on reserved pins does not break existing carrier designs outright, but the ability to boot from BIOS in a carrier LPC-attached Firmware Hub will likely disappear over time in favor of SPI-interfaced BIOS. Some module manufacturers may continue to support alternate carrier LPC-based BIOS, but in the long run, this small segment should plan to add SPI-based FLASH to support alternate carrier BIOS.

### Power Pin Reuse

COM Express applications considering migration to R2.0 need to be aware of one other important consideration regarding the 12V power pins supplied from the carrier to the module. The R2.0 specification recognized that the R1.0 specification supplied an overly generous amount of 12V power to the module. To facilitate some of the additional features and functions added in R2.0, a few of these 12V power pins were reclaimed and redefined in Types 6 and 10 while they were reclaimed and reserved in Types 1-5. Careful attention was paid to the types of functions placed on these repurposed pins such that they can be designed to be capable of tolerating 12V if generations of COM Express modules and carriers are mixed. If a design only supports the R1.0 or R2.0 specification, this pin redefinition is not an issue; however, if a carrier or module intends to support both specification generations, there are compatibility design considerations that must be taken into account. If an R1.0 carrier supports both R1.0 and R2.0 modules, the burden is on the R2.0 module to be tolerant of 12V from the R1.0 carrier on these reclaimed pins. Similarly, an R2.0 carrier that wishes to support both R1.0 and R2.0 modules must be prepared for an R1.0 module to tie these reclaimed pins back to 12V. In both cases, the burden of 12V tolerance falls on the R2.0 module or carrier and doesn't force change on the R1.0 generation parts. Refer to the COM Express R2.0 specification for further details and recommendations on supporting 12V tolerance on these signals. ↴

## SUMMARY

The COM Express ecosystem and the popularity of the Type 2 module has been based around a multi-sourced supplier base that primarily developed and adopted Type 2 modules combined with a tremendous number of widely varied applications across many segments that adopted standardized COM Express modules and built carriers specific to their application needs. The R1.0 specification laid out a course of legacy I/O interface migration on the C/D connector that, although it may have slightly missed the mark due to other changes in interface technology, did set the stage such that many carriers anticipated changes in the C/D connector and either designed to a subset of the C/D connector interfaces, or future proofed their designs by providing both legacy and forward-looking interfaces (i.e. IDE & SATA headers, PCI & PCIe slots). This trend, combined with the careful manner in which COM Express R2.0 minimized changes on the A/B connector and contained differences on C/D gives many R1.0 Type 2 carriers a simple path forward to adopting newer technologies and adding support for Type 6 modules with minimal, or no changes whatsoever.

A secondary vector of success in the COM Express ecosystem developed around smaller module sizes and the single connector Type 1 interface subset. COM Express R2.0 embraces this segment with the addition of the Compact Module size, continued support for the Type 1 module, and the addition of the Type 10 module for applications that need to migrate to newer digital display technologies.

## RADISYS AND COM EXPRESS

RadiSys takes an active role in standards development, as evident by participation with the COM Express 2.0 specification development, and with the first COM Express 1.0 specification. By actively driving and participating in standards development, RadiSys strives to balance incorporation of new technology while maintaining product upgrade paths and support of important legacy features. This overlapping of new and legacy technology in the PICMG COM Express standard and ultimately the RadiSys COM Express product line is of key importance to RadiSys customers—and remains at the forefront of our designs. See [www.RadiSys.com](http://www.RadiSys.com) for more information on the latest RadiSys COM Express products—or contact your RadiSys Account manager to learn more. ///

## ABOUT THE AUTHOR:

### BOB PEBLY— FELLOW-TECHNOLOGY OFFICE

Bob Pebly is a Fellow in the Technology Office at RadiSys Corporation, a leading provider of advanced solutions for the communications networking and commercial systems markets.. He has over 25 years experience in the embedded computing and telecommunications industry and holds a BSCS degree from Pennsylvania State University. Bob is RadiSys' primary representative in the PICMG standards organization where he has held officer positions in numerous PICMG subcommittees. Prior to joining RadiSys, Bob spent 15 years with IBM.



**Corporate Headquarters**  
5445 NE Dawson Creek Drive  
Hillsboro, OR 97124 USA  
Phone: 503-615-1100  
Fax: 503-615-1121  
Toll-Free: 800-950-0044  
[www.radisys.com](http://www.radisys.com)  
[info@radisys.com](mailto:info@radisys.com)

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