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WHITEPAPER

COMPUTER-ON-MODULE DESIGNS FOR THE FUTURE OF PORTABLE DEVICES

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CONTENTS

INTRODUCTION

For mobile and handheld device manufacturers, the evolution of Compute-On-Module (COM) products has largely been a story of more capable modules being developed to better meet the need for small size, low power, and good performance. In order to meet competitive imperatives, the need for flexibility and low cost has played a key role as well. With every new generation of technology, engineers must balance all those factors, and in doing so, they must look forward to ongoing compatibility with future components, in order to avoid costly redesign down the road.

With the introduction of the Intel® Atom™ processor, the basis for very low-power, high-performance x86-based COM modules has entered the market. Offering a combination of robustness, low cost, and small form factor, this processor has ushered in a large number of innovative, Windows-ready COM products that break new ground for portable devices as diverse as patient monitors, remote controlled robots, mobile test and measurement systems, and mobile casino games:

- Higher performance to size ratio at lower power enables smaller, passively cooled designs for a broad range of demanding applications, allowing migration from cart-based to handheld portable devices, for example.
- Better power efficiency supports longer work times between battery charges, even with frequent, power-hungry wireless communication and processing-intensive applications such as handheld ultrasound.
- Smaller form factor improves portability, enhancing manufacturer flexibility in considering which applications are suitable for the handheld and portable market.

Because of the small form factor of the Intel Atom processor, module manufacturers have been able to create modules that are smaller than the sizes specified by the PICMG COM Express standard by as much as 50 percent or more. While those small footprints enable smaller devices, their divergence from the standard adds a new layer of complexity to the choice of modules, since pin-out compatibility with existing COM Express-based device designs is not necessarily assured. Moreover, future planning must include flexibility for next-generation I/O and the obsolescence of legacy technologies like IDE and FWH, as well as avoiding vendor lock-in or the need for redesign.

ONE PROCESSOR, MANY CHOICES

The small size and low power of the Intel Atom processor and Intel® System Controller Hub US15W make them well suited to the same types of implementations that the PICMG defines COM Express to address. In fact, as shown in Table 1, the processor and chipset combination has a physical footprint that is more than 80 percent smaller than the corresponding hardware associated with the predecessor Intel® Celeron® M processor Ultra Low Voltage 423. Thermal Design Power is more than two thirds lower.

COMPONENT	FOOTPRINT	TDP
Intel® Atom™ processor (13 x 14mm)	182mm²	2.3W
Intel® System Controller Hub US15W (22 x 22mm)	484mm²	2.3W
Total footprint and TDP of two chips	666mm²	4.6W

COMPONENT	FOOTPRINT	TDP
Intel® Celeron® M processor Ultra Low Voltage 423 (35 x35mm)	1225mm²	5.5W
Intel® 945GME Graphics Memory Controller Hub (37.5 x 37.5mm)	1406mm²	7.2W
Intel® I/O Controller Hub 7-M (31 x 31mm)	961mm²	1.7W
Total footprint and TDP of three chips	3592mm²	14.4W

Table 1: *Comparison of component physical size and Thermal Design Power (TDP) requirements for Computer-On-Module designs based on the Intel® Atom® processor versus a predecessor, the Intel® Celeron® M processor Ultra-Low-Voltage.*

As mentioned previously, that dramatic reduction in size, relative to previous processors and chipsets, has led module suppliers to develop modules that are about half the size of the 95 x 125mm (Basic size) or 110 x 155mm (Extended size) that the PICMG COM Express standard specifies. Moreover, the cost of achieving the size and power sweet spot is that many features required by the specification have been left out of the chipset. This combination of factors means that the proliferation of COM products based on the Intel Atom processor are not compliant with the COM Express standard, although many are electrically compatible to different degrees. Each module also adds features beyond those provided by the chipset alone, in order to optimize for specific applications or markets.

In addition to the features provided by the chipset (which any Type 2 COM module based on the Intel Atom processor should support), the choices each module supplier makes about which features to add are the key to comparing the various COM products for a specific application. Each feature added to the module that is not supported natively by the chipset requires the module supplier to add components that increase the size, thermal dissipation, and cost of the finished module. Therefore, by determining the feature requirements for a specific application (together with your power and size constraints), you can make the optimal choice among the plethora of Intel Atom processor-based COM product options.

Retaining the size and power benefits of the Intel Atom processor in a COM product requires very streamlined module design. Likewise, overall system designs must be very streamlined as well, since incorporating add-in cards or special features will inevitably increase device power requirements, size, and ultimately cost. Smaller modules will have fewer features but enable smaller products that run cooler. Conversely, larger modules will be feature-rich but have higher power requirements and generate more heat. System-design teams coming to terms with these tradeoffs may choose flexible options such as placing specific features on the carrier, which can provide the capability for value product options with decreased feature sets and help to ensure future upgradeability.

Beyond the size and power constraints of adding components to support these features, another limiting factor is the maximum two x1 PCI Express lanes supplied by the chipset. Adding SATA and LAN options will consume both PCI Express lanes, leaving no bus connectivity down to the carrier. A bridge option to add PCI or a switch option to increase PCI Express lanes can increase the bus flexibility but add to size, power, and cost requirements. Build options for various modules related to PCI, PCI Express, SATA, and LAN define key tradeoffs associated with that choice of module.

DIFFERENTIATING FEATURES AMONG AVAILABLE MODULES

Not surprisingly, the features added by module suppliers to their Intel Atom processor-based COM products are typically a subset of the requirements of the COM Express specification. As shown in Table 2, various module types within the specification define different required feature sets. Existing and future device designs built for COM Express will incorporate and depend upon certain of these features. By choosing COM products appropriately to deliver those features, device manufacturers can navigate through the product offerings in the marketplace to obtain forward-looking module capabilities and characteristics.

RadiSys is a Premier Partner in the Intel Embedded and Communications Alliance, one of the world's most recognized ecosystems that provides a trusted supply line of Intel-based products and services. That status lets RadiSys give customers priority access to the latest technologies from Intel. In fact, not only does RadiSys deliver COM Express modules simultaneously with the latest Intel® processors—from day one, we also often have tailored carrier boards, starter kits, and thermal solutions to help you get the most out of those new products.

	SPEC MINIMUM	TYPE 1, MAXIMUM	TYPE 2, MAXIMUM	TYPE 3, MAXIMUM	TYPE 4, MAXIMUM	TYPE 5, MAXIMUM
Single connector (AB) or Double (AB, CD)	see type	Single	Double	Double	Double	Double
USB	4	8	8	8	8	8
SATA or SAS	2	4	4	4	4	4
PCI Express	2	6	Up to 22	up to 22	Up to 32	Up to 32
PCI Express (x16)	0	NONE	Yes	Yes	Yes	Yes
32 bit PCI	see type	NONE	Yes	Yes	NONE	NONE
IDE	see type	NONE	Yes	NONE	Yes	NONE
Express Card Support	1	2	2	2	2	2
SVDO	0	NONE	2	2	2	2
Dual 24-bit LVDS	0	2	2	2	2	2
Analog VGA	0	1	1	1	1	1
Tvout	0	1	1	1	1	1
AC97	0	1	1	1	1	1
Ethernet	1	1	1	3	1	3
LPC	1	1	1	1	1	1
General Purpose Inputs	4	4	4	4	4	4
General Purpose Outputs	4	4	4	4	4	4

Table 2: *Feature requirements for different module types within the COM Express specificationns.*

PCI (PERIPHERAL COMPONENT INTERFACE)

It is uncommon for new handheld and mobile equipment designs to incorporate PCI, although certain feature upgrades may require it. As one of the first generation of Intel's embedded chipsets to leave off PCI, the Intel System Controller Hub US15W avoids the requirement for a large number of pins that would otherwise be required and helps to control size and power requirements. Industry trends in general are moving toward a phase-out of PCI from new chipsets, which will require device manufacturers to add a PCI Express-to-PCI bridge if needed.

When considering the presence or absence of PCI as a differentiating factor among modules, customers should recognize that populating the bridge on the module puts the size, power and cost decision in the module vendor's hands, and it requires that all future modules used with that device design have PCI added as a separate component. Populating a PCI Express-to-PCI bridge on the carrier leaves cost and flexibility options open.

SATA (SERIAL ADVANCED TECHNOLOGY ATTACHMENT)

As a widely adopted storage-connectivity technology, SATA is used by many systems for booting the operating system. Therefore, while the chipset natively supports IDE but not SATA, most module suppliers have added a SATA option to ensure a consistent storage method on the next-generation module. Because of the legacy nature of IDE, device manufacturers must look ahead to the likelihood that it could be discontinued with the introduction of a future chipset.

Therefore, using IDE without another option in place for storage and booting the operating system will result in a shorter product-design lifespan. Based on this knowledge, future upgradeability depends upon making sure that device manufacturers' module of choice provides storage options other than IDE, such as SATA, or else a migration path should be planned for storage support on the next-generation module.

LAN (LOCAL AREA NETWORK)

LAN connectivity is not natively supported by the Intel System Controller Hub US15W, so device manufacturers must consider their options when selecting a module. The savings in thermal dissipation from leaving Gigabit Ethernet off of modules is substantial, and options to compensate for this feature gap include adding it to the module, using wireless Ethernet, or placing Ethernet on the carrier. Most COM vendors support an Ethernet option, although there are different speed ranges and implementation methods. As long as the module is routed to a Type 2 pin-out, an Ethernet option provides future upgradeability options.

SDIO (SECURE DIGITAL INPUT/OUTPUT)

Enabling a secure Flash card for use in portable devices, SDIO is not included in the COM Express specification. It also does not have assigned pins in the module types to route it to the carrier. Making use of SDIO requires either implementing a solid-state drive (SSD) card on the module or making the signal available via a header or other method.

MEMORY

While the amount and type of memory are not specified by the PICMG COM Express specification, the manner in which this feature is implemented can be critical to a system design. Depending on the size of the module, memory can be placed down on the board, or an SO-DIMM socket can be provided. The memory placed down on the board provides for a more rugged and slim module, important attributes of a handheld or mobile application. The SO-DIMM socket implementation provides memory-vendor flexibility, though the down side is that the height of the module is substantially increased.

Memory capacity can become a bottleneck for processor performance, especially when using memory-hungry operating systems like Windows Vista. COM suppliers may specify the current memory capacity or the future memory capacity (based on future memory density).

When selecting modules, device manufacturers should make sure that both the current memory capacity and potential upgrades to add memory capacity are clearly stated and sufficient for present and future application needs.

MODULE SIZE

As long as a given module adheres to the Type 2 pin-out, has an upgrade path to the next generation, and meets your current and future product needs, module size should be a relatively simple characteristic to match to devices. Table 3 provides an overview of the size characteristics of popular COM products on the market. When considering this characteristic, device manufacturers should be guided by the principle that smaller modules yield smaller products with lower cost, a guiding design principle followed by RadiSys in developing the RadiSys Procelerant Z500 module.

	MODULE SIZE	SIZE COMPLIANCE	PIN-OUT COMPLIANCE OR COMPATIBILITY	AREA	PERCENT OF BASIC SIZE
	95 x 125mm	PICMG COM Express 1.0 Basic Size	PICMG COM Express Type 2 pin out	10625mm2	100%
	95 x 95mm	None	Type 2 pin-out compatible	9025mm2	85%
Optimized RadiSys Procelerant Z500 Module	85 x 70mm	None	Type 2 pin-out compatible	5950mm2	56%
	84 x 55mm	None	Type 1 pin-out compatible (one connector)	4620mm2	43%

Table 3: *Size and related characteristics of popular COM products.*

GET THE PERFECT SIZE AND FIT FOR PORTABLE DEVICES

End-customer research by RadiSys during the pre-design phase of developing the COM product that became the Procelerant Z500 module revealed a consistent pattern of requirements—the majority of customers emphasized small size and low power to be the driving factors in determining feature trade-offs in a next-generation COM offering. Device manufacturers also reported a need for the new module to be backward-compatible with existing designs and future-focused in terms of supporting the features that are most likely to replace legacy I/O technologies. As a result, the RadiSys design team has carefully managed size, feature, and power variables to produce an optimized and ultra-small module measuring only 85 x 70mm—about half the size of a COM Express Basic module (95 x 125mm).

RadiSys Procelerant™ Z500 - Actual Size.

Engineered for maximum compatibility with existing and future device-design requirements, the RadiSys Procelerant Z500 module adheres to the PICMG COM Express Type 2 pin-out. Combined with its small size, that electrical compatibility is a key factor in making the module a stand-out choice for mobile and handheld applications. Most competing Type 2-compatible modules are 95 x 95mm in size—approximately 34% larger. A unique combination of other features completes the picture, as shown in Table 4 and discussed in the remainder of this section.

Processor	Intel® Atom™ processor Z530 @ 1.6GHz, 512KB L2 cache, 533MHz FSB, with Hyper-Threading Technology Intel Atom processor Z510 @ 1.1GHz, 512KB L2 cache, 400MHz FSB
Memory (max)	1GB, 533MHz DDR2
Chipset	Intel® System Controller Hub US15W with 533MHz FSB
I/O	· MicroSD 2 PCI Express® x1 1 IDE 1 Gb Ethernet (optional, using PCI Express x1) 1 SATA port (optional using PCI Express x1) 8 USB 2.0 ports
Display	Two independent displays (SDVO: 1280x1024, LVDS: 1366x768)
Thermal Dissipation (projected)	1.6GHz TDP: ~10 watts; Average: ~7 watts 1.1GHz TDP: ~6 watts; Average: ~4 watts

Table 4: *RadiSys Procelerant Z500 Computer On Module specifications.*

PROCELERANT™ Z500 FEATURES

PCI BUS OPTION

While current device designs must accommodate a future without legacy bus functions such as PCI, many applications require PCI, making it an important capability for the near future. At the same time, providing a PCI Express-to-PCI bridge on the module would add expense that would not be needed by many devices. RadiSys addresses these considerations by allowing device manufacturers to incorporate the PCI bus function in the carrier design, if needed, for an optimal combination of high flexibility and low cost. The PCI pins on the COM Express-compatible connector will have no signal and will not require any special handling.

SATA OPTION

The Procelerant Z500 module incorporates SATA as a board option that can be populated using one of the two PCI Express lanes if required or left off if not. The SATA option is routed to be compatible with the Type 2 pin-out. On-board SATA provides access to a long term storage solution as the IDE peripheral market declines.

WIRED LAN OPTION (GIGABIT ETHERNET)

While mobile and handheld applications will typically use wireless LAN connectivity for transferring data, customer feedback indicates unequivocally that tethered products require wired LAN connectivity for low-noise transmission. In a similar fashion to the SATA option, the Procelerant Z500 module enables Gigabit Ethernet to be populated if desired as an optional board component using one of the two PCI Express lanes. The LAN option is routed to be compatible with the Type 2 pin-out.

SDIO SUPPORT

As discussed in the previous section, the SDIO feature is not included in the COM Express Type 2 pin out, and there are no "user pins" to route it to the carrier. The Procelerant Z500 includes a latched MicroSD socket on the module for additional onboard storage, in order to better target mobile and handheld devices. The MicroSD socket requires corresponding support in firmware, which can be upgraded to support a boot option from the MicroSD card. This provides another consistent booting option in addition to SATA that can carry designs forward from this generation module to the next.

MEMORY

The RadiSys Procelerant Z500 module incorporates eight memory devices soldered down on the board, providing the 1GB maximum memory supported by the chipset. The build option exists to place larger memory chips onboard for a total of 2GB, if the chipset is upgraded in the future. Onboard memory reduces the module height substantially compared to an SO-DIMM socket and enhances the ruggedness of the module in shock and vibration tests. While 1GB onboard memory is mandatory both to support many operating systems and to enable optimum processor performance, board options are also provided to de-populate the memory to 512MB.

BATTERY SUPPORT

Validation over an extended supply voltage range of 9-16.8V enables the module to support very flexible direct battery hookup. Most lithium-ion batteries can be discharged down to around 3.0V before the battery controller must shut the system down in order to prevent battery capacity from being permanently diminished. Thus, validation of the module input power supply voltage down to 9V enables the module to extract all the available energy from a three-cell lithium-ion battery without requiring a boost regulator to raise the voltage. Likewise, cells are typically charged to 4.2V, so validation of the module up to 16.8V allows it to run directly from a four-cell battery without a buck regulator to reduce the module input voltage during charge. Eliminating these two voltage regulators from the system design can save 10-20 percent in power efficiency, helping to extend battery life and reduce heat generation.

TYPE 2 COM EXPRESS COMPATIBILITY

Current applications based on the Type 2 COM Express pin out can use the Procelerant Z500 module as a drop-in replacement by using the innovative RadiSys mechanical adapter/heat spreader represented in Figure 1. That capability provides a path for use in existing COM Express designs as well as a foundation for next-generation devices. It also enables the easy addition of a value-priced option into existing COM Express product lines. ETX users who are ready to leap from parallel to serial I/O can look to the Procelerant Z500 as an ideal crossover point from a size, power, and price perspective.

"RadiSys has extended the capabilities of standards-based COMs again with the Procelerant Z500 module. RadiSys has zeroed in on the key module features required to stand out in handheld and mobile applications, such as the focus on battery support and ACPI implementation."

"In addition, they shrunk the module form factor while keeping it electrically compatible with Type 2 COM Express products. That gives device makers the best of two worlds—they can improve the power/performance profile in existing designs, as well as making future, handheld, and mobile devices smaller and more thermally efficient."

Eric Heikla
Analyst
VDC

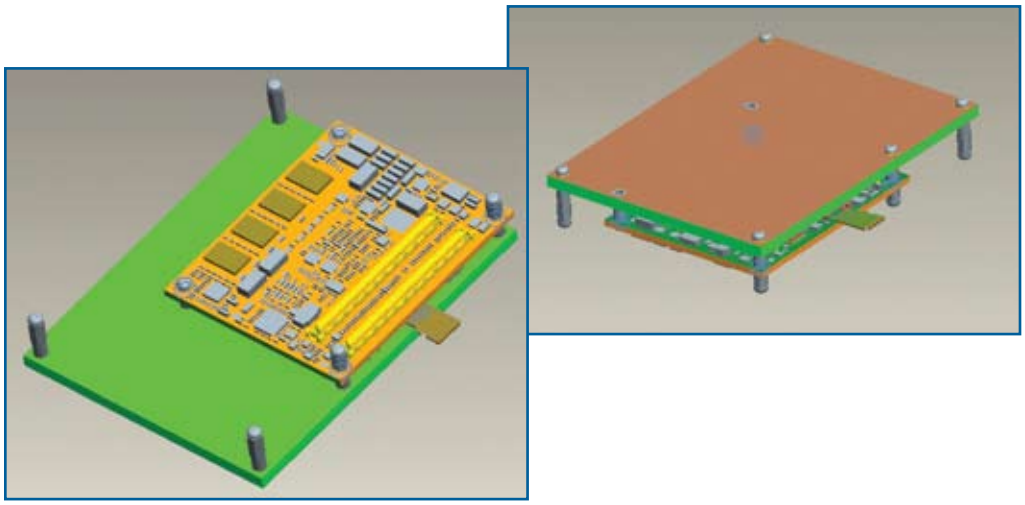

Figure 1: *Heat-spreader provides mounting site specifically for Procelerant Z500 module and doubles as an adapter to Basic Form Factor mechanical footprint, enabling use of the new module with existing COM Express designs.*

COLLABORATE WITH THE COM EXPERTS

The Procelerant Z500 module extends the traditional benefits of COM Express with future-looking design flexibility, and collaboration with the COM Experts at RadiSys positions device manufacturers to get the most out of those capabilities. RadiSys thought leadership and engineering expertise is the culmination of a history of COM innovation that stretches back 20 years and that helped drive the original PICMG COM Express specification.

Compatibility with the COM Express specification enables the Procelerant Z500 module to deliver a modular processor/memory subsystem that is separated from design-level IP. That approach brings the time and cost efficiencies associated with the module's high-volume manufacturing to low-volume device manufacturing, increasing the competitiveness of finished system designs. The Procelerant Z500 delivers advanced integrated graphics capabilities that yield price and size advantages by removing the need for a dedicated graphics card in many implementations such as ultrasound and ruggedized handhelds.

RadiSys is uniquely positioned to help its customers take full advantage of the COM advantage through leadership, innovation, and collaboration:

- **Leadership**: Driving the next generation of COM with unmatched industry knowledge and experience, RadiSys provides a broad product portfolio that delivers the right balance of performance and value for the full range of embedded applications.
- **Innovation:** Starter kits that provide matched components for fast design startup, development carrier boards that jump-start product development and custom thermal simulation and solutions that reduce device-design complexity are just some of the advantages that RadiSys customers benefit from every day.
- **Collaboration:** With RadiSys on your team, you have expert help in areas like BIOS customization and custom carrier design and development. RadiSys engineers provide in-depth design review, validation, and testing that helps bring your products to market quickly, reducing missteps and development costs.

The Procelerant Z500 module breaks new ground in size, power, and cost, enabling device manufacturers to break into new markets with portable devices that sport attractive price points and battery life, making them more competitive. More than two decades of design expertise from RadiSys are manifested in this new COM product and the support system that enables customers to get the maximum advantage from it, simplifying the device development cycle. Your focus is on developing products that drive success. Our focus is on helping you get there faster, and no one does it better.

Surgical Equipment and Patient Monitors:

- Robust graphics with dual-display option
- Low-power, fanless design
- 1Gb Ethernet connectivity
- Common architecture for entry and high-end devices

Handheld Industrial Computers:

- Low power, fanless design
- Small size
- Integrated graphics
- Long battery life
- Rugged memory and storage implementation

Test and Measurement:

- Low power, fanless operation
- Compact size
- Long battery life
- 1Gb Ethernet connectivity
- Upgradeable to support long product life

CONCLUSION

With the introduction of the Intel® Atom™ processor, handheld and mobile device manufacturers have the capability to meet extreme demands for low power and small size with the cost advantages and broad ecosystem associated with x86 architecture. The cost advantages of COM products based on this new processor have ushered in a rush of modules that are compatible (though not compliant) with the COM Express specification. Because the size advantages of these modules are fostered in part by the scaled-back features offered by the Intel chipset, module suppliers must choose a feature set to add beyond the chipset capabilities. The resulting variation adds to the complexity that device manufacturers face in choosing among the modules.

RadiSys thought leadership positions the RadiSys Procelerant Z500 module as an optimal solution that marries size, power, and cost advantages while delivering compatibility with both predecessor and future COM-based device designs. Together with the support products and services that RadiSys offers in support of devices based on this set of innovations, the Procelerant Z500 provides the basis for a winning next generation of embedded devices and ongoing success for device manufacturers in collaboration with the COM Experts.

> "Our customers can now base their handheld and mobile products on an extremely compact, high-performance, and rugged computer-on-module that is compatible with the Type 2 COM Express pin-out. The RadiSys Procelerant Z500 module will also provide existing COM Express users the benefit of adding to their product lines while retaining the time-to-market advantage of COM Express. Coupled with the RadiSys heatspreader/mechanical adapter, this new module can be a drop-in replacement for existing Basic Form Factor designs."
>
> Wade Clowes
> Vice President
> RadiSys Commercial Segment

TAKE THE NEXT STEP

Collaborate with the COM Experts at RadiSys to unleash the capabilities of next-generation technologies with design stability you can count on.

For more information, see the Procelerant Z500 Product Data Sheet or contact your RadiSys sales manager.

ABOUT THE AUTHOR

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Jennifer Zickel is a Product Manager for the COM Express Product line at RadiSys. She has a B.S.E.E. degree from New Mexico State University and over 10 years experience in the embedded board market in Product Line Management, Engineering and Marketing roles. She has worked with components, board and system level products from the latest technology to older legacy technology. In addition to her RadiSys experience, she has worked for Intel, Texas Instruments, and Lattice Semiconductor.

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