

# Custom Carriers Maximize the COM Express Advantage

## Overview

In the current era of business management, companies of all sizes work toward the goal of tightly managing resources, as a means to maximize profitability. There has been a wave of downsizing and outsourcing in the past years, as in a variation on the theme of just-in-time supply chains, many organizations use contractors and other contingent workers extensively to manage peak requirements. This strategy allows companies to retain a skilled and focused employee base that can be kept stable during downturns. However, as a result of this strategy, the downsizing and outsourcing can create a knowledge gap within the core permanent employees of companies and increase dependence upon contractors and other external resources.

While managing corporations under this model can indeed increase profitability, it also requires technical project leaders to look outside of regular staff employees for hardware and software design expertise. Since it is necessary to have consistent and dependable means of fulfilling these goals, one effective strategy is to reduce dependence upon custom hardware configurations by using standard building blocks. This approach can reduce the cost of hardware by using commercial-off-the-shelf (COTS) products in place of custom ones, and at the same time, it reduces dependence upon project-dedicated hardware designers and helps to speed up-time to market.

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Even as project managers find success using COTS motherboards and systems, they also find many situations where this hardware simply can't fill their needs. For example, requirements may arise with regard to shape, size, or thermal characteristics that can't be met with COTS equipment. Therefore, advancing this project model requires a combination of standardization to reduce hardware-design requirements, control costs, and speed up time to market, while also supporting advanced customization.

The COM Express standard is one means of providing this combination of benefits. Providing integrated combinations of processor, chipset, memory, and other components with specified mechanical, electrical, and thermal requirements, these modules provide a standardized core for custom systems, as shown in Figure 1.

COM Express provides application-specific I/O baseboards and a modular design that supports drop-in upgradeability, for extended life using future CPUs. The modules also support internal and external graphics, multiple display devices, audio, networking, storage, and various I/O and expansion interfaces. They relieve project teams from being concerned with many aspects of system design while also allowing for customization at the board level, shortening time to market, and cutting project costs.

For more technical information on COM Express, see the white paper "COM Express: The Next Generation Computer on Module Standard."

## Extending COM Express with Custom Carriers

In order to provide application differentiation, it is often necessary to customize the carrier board that houses the COM Express module and other components. While modification of a standard board often represents only an incremental degree of change from the off-the-shelf product, it nevertheless consumes project resources and requires expertise that may not be readily available. For that reason, many customers turn to module suppliers that have years of experience designing and testing modules

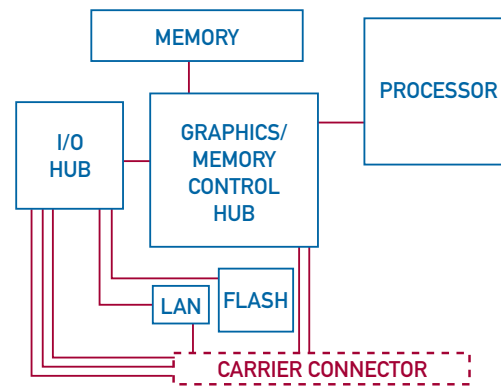


Figure 1. A Typical COM Express Module

to work with various types of carriers. This expertise helps to ensure the success of the design, including stability, upgradeability, and adherence to project performance, power, and thermal specifications.

Custom carrier implementations carry a number of advantages by enabling project teams to use standards-based, merchant-supplied modular building blocks to develop unique systems. By combining their internal development efforts with the specialized capabilities of custom carrier vendors, these customers are able to more efficiently meet their project goals, faster and at lower total cost of ownership. This design modality avails them of the full spectrum of widely adopted technologies such as Ethernet, IP, Linux, media processing, and CPU, GPU and NPU processors, while reducing the burden on internal resources in terms of both time and expertise.

These purpose-built boards provide programmable, intelligent, networked functionality to a wide variety of applications, including image processing, test and measurement, automation, transaction management and data communications. By removing a large part of hardware design from the responsibility of the customer's development team, the use of custom carrier boards enables that team to focus engineering resources into more value-added activities. Since product teams can spend their resources adding features and functionality to the final result, their products stand to gain a competitive advantage.

Many companies that build standard COM Express and carrier board products also offer custom design and fabrication services that include a wide range of capabilities from fast prototyping to complex testing. These services can provide faster time to market, making development more cost-effective, but customers should be aware that vendor selection in this area is far from being a generic commodity. Even assuming first-rate design expertise, vendor quality varies, and selection is a complex undertaking that has a tremendous bearing upon the success of bringing a product to market.

Specific key elements of the vendor-customer relationship are vital to the success of a custom carrier project. For example, customers should be free to assume whatever depth of involvement they choose into the board design, from submitting only core requirements to providing a comprehensive design, while retaining control over all their intellectual property. Vendor services should be comprehensive, throughout the product lifecycle, and the customer must be assured of thorough design validation and unit testing. Contingent fees must be agreed upon from the start, with guarantees that unexpected changes like a product redesign in mid-project will not jeopardize success.

## Company Partnership and Collaboration

When a company brings an outside organization into the product-development effort to fill a role as vital as custom carrier design and development, the design partner must act as a “virtual division” of the hiring company in order to be successful. There must be a strong relationship between the companies that includes open and robust engineering collaboration, extending up to senior management. Both parties must recognize that they have a common interest in the success of the current product effort that may extend into the long-term future.

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*“Our strategy is to deliver standards-based, fully integrated, application-ready embedded platforms that allow customers to focus their resources on developing features that differentiate their products.”*

*Wade Clowes, General Manager,  
Radisys Commercial Segment*

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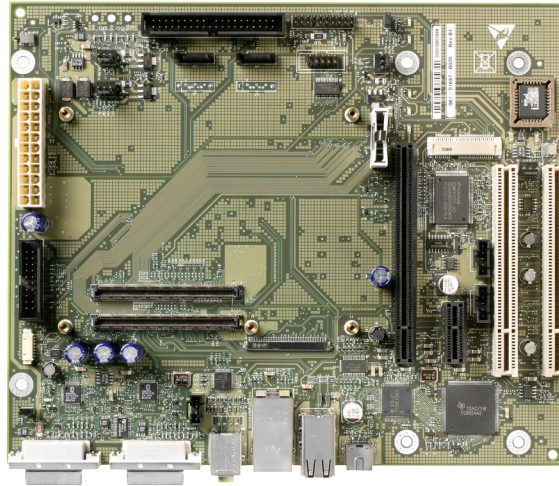
In addition to having a culture that fosters this degree of collaborative involvement, the vendor must also have a proven track record of successful development, financial viability, and the scope of services to encompass integration, manufacturing, R&D, and supply chain and lifecycle management. The vendor of choice to fill this role should provide an interdisciplinary pool of embedded computing expertise, including application consultants, hardware engineers, and program managers. Vendor staff must ally themselves fully with the rest of the team, including a willingness to adjust to unexpected circumstances and special unforeseen requirements.

It is important when considering a partnership such as this one to distinguish the different focus of contract manufacturers as opposed to engineering companies. Contract manufacturing firms often offer some degree of engineering services at additional cost, but full-lifecycle project support is not their core competency, which can have an adverse effect on the outcome of a project. Design engineering firms, with a standard product base, specialize in product management, as well as often provide value-added manufacturing services. Because the latter type of organization holds design support as a core competency, it is a better choice for an integration project such as custom carrier design and development.

Similarly, while considering how the design partner fits into the entire scope of product design and development, it is also important to consider how the relationship with that vendor and the custom carrier design itself fits into a longer-term product-development strategy. That is, when determining the value of a custom-carrier design, it is necessary to do so from a total-cost-analysis point of view. The right engineering expertise can help to develop a solution that optimizes design and redesign flexibility, for lower long-term cost. This consideration is another reason that partnering with a firm that has expertise in creating flexible custom carrier designs pays off.

As an example of reuse in carrier design, many customers have a range of products with similar core requirements but different card-level requirements. A flexible card design allows these customers to extend the initial engineering effort associated with card development, creating variations with less effort, time, and expense than would otherwise be possible. As an additional advantage, those customers can manufacture the cards in low volume while also realizing the cost advantages of high-volume COM Express modules. Building these levels of flexibility into a custom card design is a sophisticated undertaking that benefits from the long-standing expertise of a top-tier embedded-system design firm.

As mentioned previously, the engineering relationship between the customer and design partner should allow flexibility in terms of how much or how little of the carrier-level design is performed by the customer. Expertise and experience across this spectrum is another important decision criterion when choosing a design partner for a long-term relationship, during which roles and process may change. While some companies will engage a design partner with only a general idea of the functional requirements of the system, others may prefer to perform some prototype work on their own. One way to facilitate such prototyping is by the use of development boards such as the Radisys Procelerator™ CR100 Flex ATX carrier board, shown in Figure 2. These boards can also serve as a baseline for the development of production systems.



**Figure 2.** *The Radisys Procelerator CR100 COM Express Development Carrier*

## Project Management Interfaces and Processes

As already discussed in this paper, a custom carrier design company has very important and long-term role in product development that it must act as a “virtual division” within the customer company. Implementations of custom boards commonly serve customers in fields that include medical imaging and monitoring, test and measurement, industrial automation, transaction terminals, and gaming.

As part of its commitment, the design partner must provide cradle-to-grave accountability for product development, production, and lifecycle management. It must also share in the responsibility for project coordination, beginning with the initial development phase and carrying through to the entire life of the product. In order to fulfill this responsibility, the design partner must provide dedicated individuals as interfaces to the customer’s organization, including a technical interface (customer advocate), manufacturing program manager, quality engineer, materials program manager, and lead test engineer.

Those team members must be accompanied by processes that ensure the smooth operation of the relationship throughout the life of the project. Regular, formalized contact between both management and engineering staff of the two companies is essential, as are service-level agreements to solidify expectations and escalation paths for the resolution of issues that arise during development. Division of tasks must be clear from the onset, with the design partner taking responsibility for documenting product specifications, as well as plans for validating the design and unit testing the finished products. A design partner with expertise in this type of customer interaction is essential to the success of the project.

The design partner must be highly proficient at project management, and it should document the full scope of its responsibilities before actual work begins, maintaining that documentation during the lifecycle of the project. Typically, the scope of the design partner's tasks should include at least the following aspects:

- Develop a project plan to detail the development tasks, schedule, and defined contacts and team members
- Develop the product specification, to crystallize the solution according to the customer's business and technical needs
- Provide logic design, schematic capture, board layout, mechanical design, and BIOS development based on the approved product specification
- Host design reviews at appropriate critical schedule decision milestones
- Develop and supply functional prototypes for design validation and code development
- Perform validation testing to meet the requirements of the product specification
- Develop manufacturing assembly and test routines to optimize efficiency and quality
- Supply production units to the customer based on a long-term purchase agreement

## Design and Manufacturing Expertise

Custom carriers range from the very simple to the very complex. They always include at least one interface for a COM Express module, one or more types of external I/O (e.g., PCI Express, Gigabit Ethernet, graphics bus, USB), and power delivery. In more complex boards, multiple COM Express modules and other integrated circuits may communicate with one another via PCI Express, Gigabit Ethernet, or both. Regardless of their complexity and individual requirements, every card design involves similar types of considerations. The primary areas of design complexity include physical and mechanical (especially component height), electrical (impedance matching, termination, noise, and transmission line noise), and control interfacing (carrier card to module) considerations.

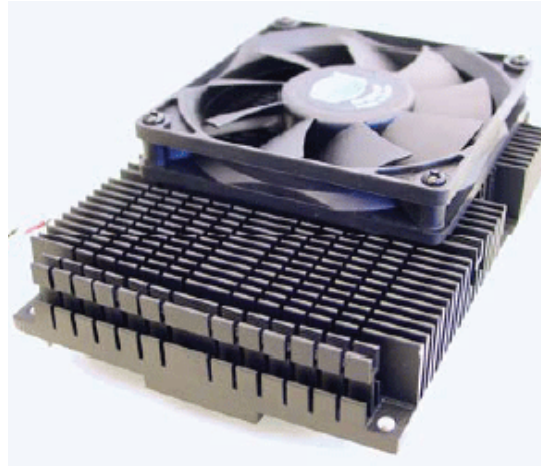
These design issues can become highly complex, and many of them are specific to carrier card design. Because most organizations do not have that specific system-level expertise within their engineering organizations, having a hardware provider that specializes in this area is a sound decision. Radisys has extensive experience in custom carrier design, which has been an important part of its business since the company was founded in 1987. The company is also an ISO 9001 and TL 9000 certified maker of COM Express modules, representing a significant value proposition to its customers.

When a customer engages Radisys to design a custom carrier card, they don't have to concern themselves with issues that lie outside their core businesses. Instead, they allow Radisys to integrate with their product teams to provide customization services, a Radisys core competency. That allows the customer to focus on value-added activities such as adding features and functionality to their products, taking better advantage of their domain expertise and adding to the overall product competitiveness.

Radisys expertise extends to a wide variety of relevant specialized design and development areas. For example, nearly every COM Express custom carrier requires some level of BIOS customization. Radisys has extensive engineering experience in this area, as well as the licensing necessary to modify commercial BIOS packages. Similarly, thermal issues in carrier design require highly specialized skill sets that most engineering organizations lack, but which represent a Radisys core competency. For example, heat-dispersion requirements extend beyond the capabilities of the standard heat spreader provided by the COM Express specification. Radisys can create custom heat sinks that are contoured to match up precisely to the components on the COM Express modules, for superior heat dispersion.

Radisys also performs other types of thermal design and engineering, such as modeling the thermal properties of a system operating under load within a custom enclosure. Because this type of design is beyond the capabilities of the typical engineering staff, products developed on their own could be forced either to over-compensate for potential heat issues, which adds to the cost of the solution, or to rely on trial and error, which can open the project to failure.

A single custom carrier card can be designed to accommodate a choice between several different COM Express modules, as in cases where a range of performance levels or thermal properties is desirable, at different price points. This capability allows the production of several product versions with only one design burden, simply by swapping out a high-cost or a low-cost COM Express module. Likewise, properly designed carrier boards can accommodate future designs of processors and chipsets using new modules. This area represents another advantage of selecting Radisys as a design partner, because of the company's long-standing domain knowledge in designing boards that reliably meet these types of requirements.



**Figure 3.** Custom Heat Sinks Developed by Radisys Provide Advanced Thermal Performance

Radisys can also design custom carriers to accommodate more COM Express modules than are needed immediately, which allows customers to scale capacity with additional modules, similarly to adding more processors to a server. The ability to simply add more COM Express modules instead of more boards saves on equipment and operating costs. For more information on the technical issues associated with carrier card design, see the following white papers:

- “Successful Carrier Card Design for COM Express: Introduction to High Speed Serial Bus Interface Design”
- “Successful Carrier Card Design for COM Express: Introduction to Thermal Design Considerations”

## Post-Manufacturing Support

After a carrier board is manufactured, Radisys testing procedures help to ensure that each unit meets the approved functional specifications for that product. Radisys certifies that finished units function using the operating system and drivers in the design specification, within the correct operational range of all test parameters. As the customer completes assembly and testing of the larger system that the carrier board is

part of, Radisys also provides comprehensive consulting services as necessary to ensure the optimal operation of the board in production.

After the design and build stages of a project are complete, Radisys stands ready to assist with any engineering requirements that arise throughout the lifetime of the product. During the post-implementation phase, for example, the customer may choose to upgrade the operating system used.

## Standards-Based Design Wins for High-End Imaging Applications

High-end image processing has traditionally been the domain of specialized and proprietary hardware, which has added significantly to the expense of the systems that support these applications. Because of its proprietary, non-standardized nature, this specialized hardware also carries with it the liability that software is often not portable between platforms. Most high-end imaging applications can be classified into one of two categories:

- *Visualization applications* produce an image or set of images. Examples include medical imaging, various military imaging applications, and luggage, cargo, and passenger screening.
- *Machine vision applications* produce a decision based on a set of images. Examples include inspection of food or manufactured goods, robotic assembly, autonomous vehicle navigation, and fingerprint or facial recognition.

Recent advances in standardized hardware, like that integrated into Radisys COM Express modules, have made it increasingly viable to support these high-end applications with commercial off-the-shelf (COTS) hardware.

Multi-core CPUs pack the processing power of multiple processors onto a single chip, and other architectural advances build performance even further. High-speed, bi-directional serial interfaces such as PCI Express (PCIe), Serial ATA (SATA), and Serial Attached SCSI (SAS) overcome previous I/O limitations. DDR2 plus fully buffered DIMM memory completes the picture, with great performance increases over its predecessors. This paragraph does not look very connected to one before and after it.

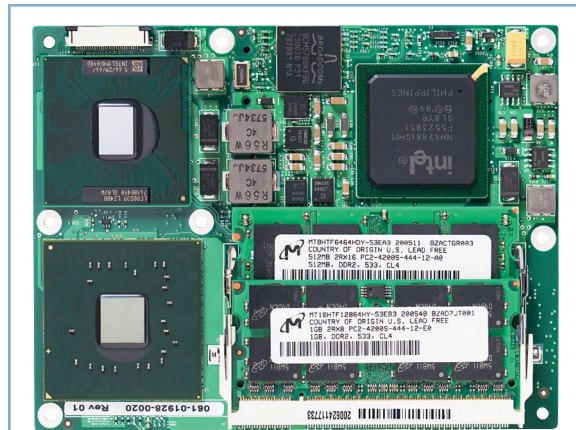
A key advantage of standards-based hardware to imaging system manufacturers is that high manufacturing volumes drive much lower costs and faster development than for proprietary systems. In addition to those benefits, manufacturers of combined hardware/software solutions for high-end imaging applications obtain a variety of other advantages from COTS hardware:

- They can design high-performance systems that have the bandwidth to rapidly process large datasets and complex mathematical operations inherent to the applications.
- They can preserve their investments in application software and firmware when shifting to the next hardware platform in order to avoid lengthy recoding and testing.
- They can deliver solutions that can easily scale in performance, through different product configurations, field upgrades, and by moving from one platform generation to the next.
- They can drive down their prices, making themselves more successful in competitive markets.

That change can cause a cascade effect, where the BIOS, drivers, and even the thermal solution need to be modified as well. Radisys can help not only to determine the scope of these changes that are required, but also to actually perform them for the customer. Likewise, Radisys can provide design support to determine the nuances associated with upgrading to a COM Express module that was not included in the original functional specification of the system.

Carrier boards are typically engineered to provide continued availability of identical components throughout a typical span of about seven years, helping to avoid system redesign and re-qualification costs. Part of this effort to provide system-design longevity consists of taking good advantage of the long-life roadmaps put in place by its component suppliers. This is another area where long-standing participation in the product ecosystem helps Radisys to provide excellent quality in its designs. Radisys has deeply established relationships with peers and suppliers in the industry that are very valuable in providing access to long-range technology forecasts that ultimately benefit its customers.

For companies that maintain repair departments for their products, Radisys provides support in a variety of forms. For example, it helps those companies make sure that they have the right type and quantity of spare parts to maintain a high level of quality in their repair operations. Training opportunities for repair technicians also help to ensure that troubleshooting and repair of systems submitted for service are performed efficiently and successfully. Another option is for Radisys to provide a fully outsourced repair service for its customers. Because of its intimate knowledge of the systems being repaired, Radisys can perform diagnostics and repairs promptly and accurately. Moreover, Radisys can detect recurring issues that arise with products and perform engineering reviews when necessary to help resolve underlying problems, improving product reliability over time.



## An Industry First: Dual-Channel COM Express Performance

Leaps forward in processor performance give systems designers the horsepower to support performance-hungry applications like medical imaging, test and measurement, and industrial automation at attractive price points. COM Express provides an ideal way to package that processing power for applications that require compact form factors.

A key consideration in delivering that performance is the provision of dual-channel memory to feed the data-hungry processing engines. Unfortunately, the industry has been unable to squeeze two SODIMM memory modules onto the 95mm x 125mm COM Express module. The Radisys Proclerant™ CE945GM is the industry's first COM Express module to provide dual-channel memory along with the Intel® Core™ 2 Duo processor, for breakthrough embedded performance.

## Supply Chain and Lifecycle Management

The Radisys engagement model involves responsibility and accountability throughout the product lifecycle. As already discussed, it begins in the pre-design phase of the project and follows through continuously, during the design, engineering, manufacturing, and post-release phases. The value added through partnership with Radisys also extends to the management of the supply chain during product production. Because it is the actual manufacturer of many of the components used in custom carrier projects, a substantial portion of the supply ecosystem falls automatically to Radisys. The company extends that responsibility further, using its long-standing industry relationships and expertise to manage the supply chain for continuous improvement, lower cost component alternatives, and seamless technology transitions throughout the product lifecycle.

Radisys complements its mature market presence with the agility to adapt its production mechanisms and systems to the needs of individual customers. By minimizing the need for its customers to make compromises with regard to their own processes, Radisys helps to safeguard customer success and integrate new projects with established ways of doing business. That flexibility extends to dynamically adjusting the size and length of production runs, including small or large batches, over whatever time horizon the market dictates. Radisys can provide consulting support to end-user organizations, provide drop-shipping and support expertise, and any of a wide variety of services on an as-needed basis.

Excellent processes and systems are in place to manage inventory effectively, minimizing the capital expenditures needed on the part of Radisys customers to maximize flexibility and revenue. Advanced

inventory-management capabilities include flexibility between the dexterity of just-in-time fulfillment to minimize holding costs and the relative safety of surplus stock in a Kanban model. Radisys has long-standing expertise in both these techniques, and it tailors the inventory process to the needs and strategies of each customer.

The corporate headquarters and primary manufacturing site for Radisys products is located in a 130,000 square foot facility in Hillsboro, Oregon that also serves as the main distribution center. Dynamic stress testing of components and systems at this location helps to safeguard product reliability, durability, and long life. Radisys also maintains relationships with a number of contract manufacturing partners that provide approximately 70 to 80 percent of the company's manufacturing capacity, which helps to deliver better global customer fulfillment and reduced cost. The company's global reach also includes design and testing centers located in the United States, Canada, and China.

During production, all the design and other data necessary to build the custom carrier files is placed in escrow, as further assurance of ongoing fulfillment for the customer. In the event of an unforeseeable catastrophe or other interruption to production, the customer organization has the ability to immediately access this information and to use it royalty-free to produce the products by alternate means. After a pre-agreed period, ownership rights to that information shift entirely to the customer. Growing from the philosophy that customer success is a prerequisite for Radisys's success, this equitable treatment of manufacturing information capital is another means by which Radisys helps to safeguard the interests of its customers.

## Conclusion

The philosophies, processes, and expertise embodied by Radisys and described in this paper are a roadmap for customer success with products based on COM Express modules and custom carrier boards. That success has proven itself over and over, standing the test of time. Every custom design partner that a customer considers partnering with should exhibit these characteristics and capabilities. Vendors that don't, represent a risk to the viability and ongoing success of the product under development.

Of course, the real proof of a partnership's value is in the results. An important part of the due diligence called for in vendor selection, in addition to all these other factors, is to carefully review their references from long-standing customer relationships. By interviewing those customers, one can gain insights into some of the intangible aspects of working with a company, such as how responsive they are, both at the beginning of a project and after it has been underway for a number of years, and both when things are going smoothly and when difficult issues arise.

Radisys is credited with being a pioneer by offering custom design partnerships twenty years ago, and it continues with a large and diverse set of core competencies that support that mission today. The ability to fully integrate with another company as a virtual division makes Radisys a unique and extremely valuable resource in the development of custom carriers for flexible, fast-to-market, cost-effective COM Express solutions. From the simplest designs to the most complex, Radisys brings its proven development processes, design expertise, and ability to add unique value at all stages of the lifecycle to bear on custom projects for its customers.

Take the next step:

- To learn more about Radisys COM Express products, visit [www.radisys.com/products/COM-Express.cfm](http://www.radisys.com/products/COM-Express.cfm).
- To contact a Radisys representative, visit [www.radisys.com/corporate/contactus.cfm](http://www.radisys.com/corporate/contactus.cfm).

The Radisys logo consists of the word "radisys" in a lowercase, sans-serif font, with a registered trademark symbol (®) to the right. The logo is set against a dark red rectangular background.

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