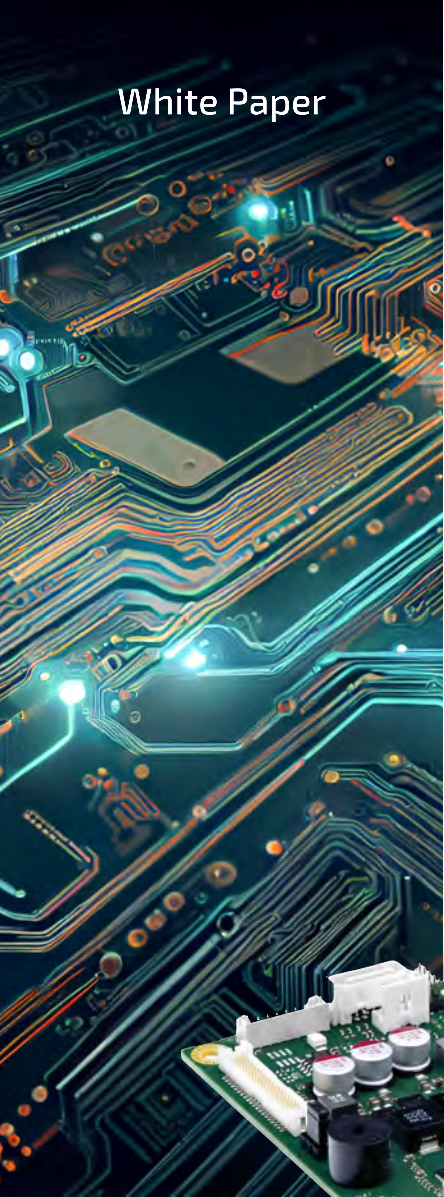
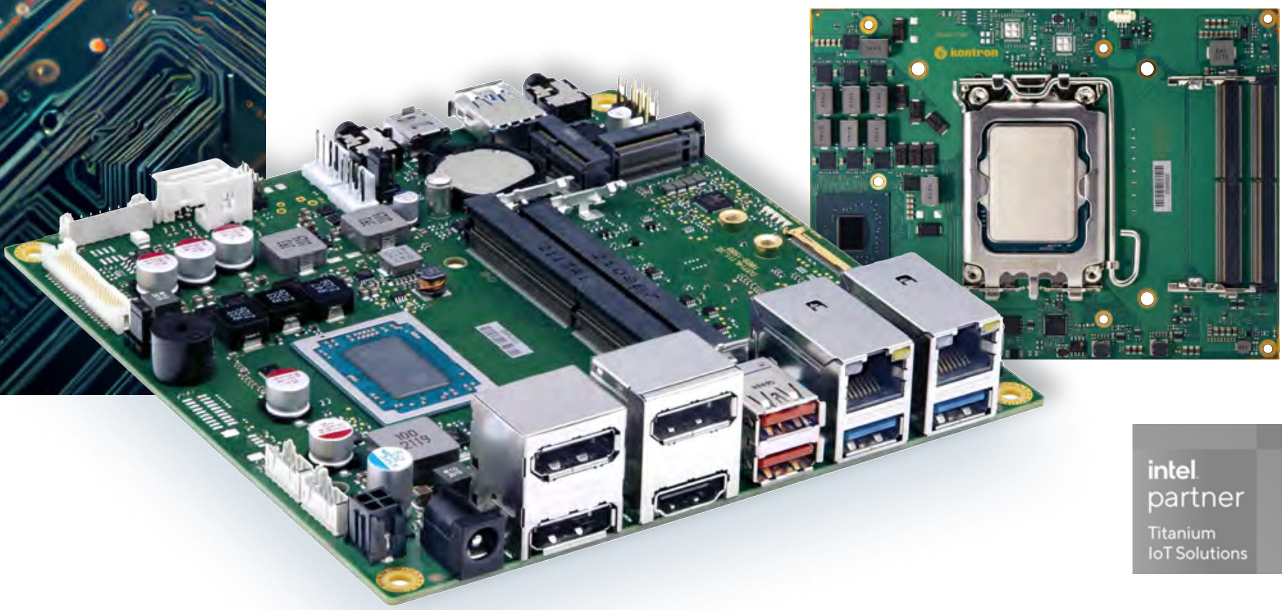


White Paper

Selecting Motherboards and Modules:

Key Considerations for System Design

In-depth Analysis of Performance, Cost, and Flexibility Factors



When it comes to designing embedded computing platforms, developers like you play a crucial role in making a choice between the all-in-one functionality of motherboards or the customizable, modular approach offered by computer-on-modules (COMs). This decision significantly impacts design flexibility, performance, cost, and, ultimately, the product's success in the market. Your expertise and understanding can make the difference between a successful product and one that needs improvement. However, we understand that it may not always be clear which option is best for a given application. That's why we've outlined the various factors that would impact that decision. This whitepaper breaks down the criteria influencing these choices, making it accessible for you to align your hardware decisions with your application needs effectively.

kontron
The Power of IoT

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The Power of IoT

Introduction

Embedded computing platforms form the backbone of various industrial, medical, and consumer applications. Choosing the right platform—motherboard or COM—is pivotal, as each offers distinct advantages and challenges. Developers look at different options in the decision-making process. One decision that could determine the product's success (or failure) is whether to employ a standard motherboard versus taking a modular (computer-on-module, or COM) approach, where the module plugs into a carrier board. The motherboard generally comes loaded with features, while the COM offers more flexibility.

In this whitepaper, we will provide guidance to help you, as a developer, to make the most suitable choices, which will determine the success of the application in the long term. And frankly, getting it wrong could be costly. We will lay out all the relevant options so you can make informed decisions. As always, there may be extenuating circumstances beyond this paper's scope, and we will keep our terminology relatively broad.

Concerning the end application, this whitepaper will focus on motherboards and modules for the following industries, including:

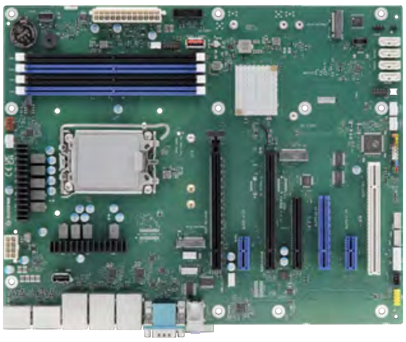
- Industrial applications, including automation, robotics, and testing.
- Transportation, emphasizing durability and reliability.
- Medical/healthcare, with unique needs like robotic surgery.
- Energy and defense sectors, focusing on efficiency and security.

What is a Standard Industrial Motherboard?

An industrial embedded motherboard is built to a standard size/form factor and contains the necessary connectors, expansion slots, and I/O interfaces to meet the computing needs of most common applications. Due to their standardized form factors (2.5 and 3.5 in., mini-STX, thin-ITX, mini-ITX, µATX, and ATX), a comprehensive set of complementary components are available, including chassis, power supplies, and cooling solutions. These motherboards must pass comprehensive functional and stress tests to ensure reliability across various applications and industries.

Motherboards feature a combination of CPU, memory, storage, and peripheral interfaces tailored to the requirements of the intended use case. They are expected to operate for long periods, potentially decades, making them ideal for embedded applications.

Various industries and applications, including industrial automation, automotive systems, and medical devices, commonly use embedded motherboards. They come in multiple form factors and custom designs within a product family, allowing flexibility to fit different-sized physical enclosures. Specialized features such as ruggedized construction, extended temperature-range support, or enhanced I/O connectivity options are incorporated to meet the demands of challenging environments.



ATX:
304.8 x 243.8 mm
(K3851-R ATX)

Micro-ATX:
243.8 x 243.8 mm
(K3843-B2 µATX)

Mini-ITX:
170 x 170 mm
(K3833-Q mITX)

Mini-STX:
140 x 148 mm
(K3921-N mSTX)

Industrial Motherboards based on Intel® Core™ Processors (14th Gen)

Watch video

Deeper Dive into a Motherboard

Motherboards are built to standardized form factors, ensuring compatibility, and reducing mechanical issues. They offer sufficient connectivity, features, and functionality for most applications, with extension cards (M.2, PCI, PCIe) available for additional needs.

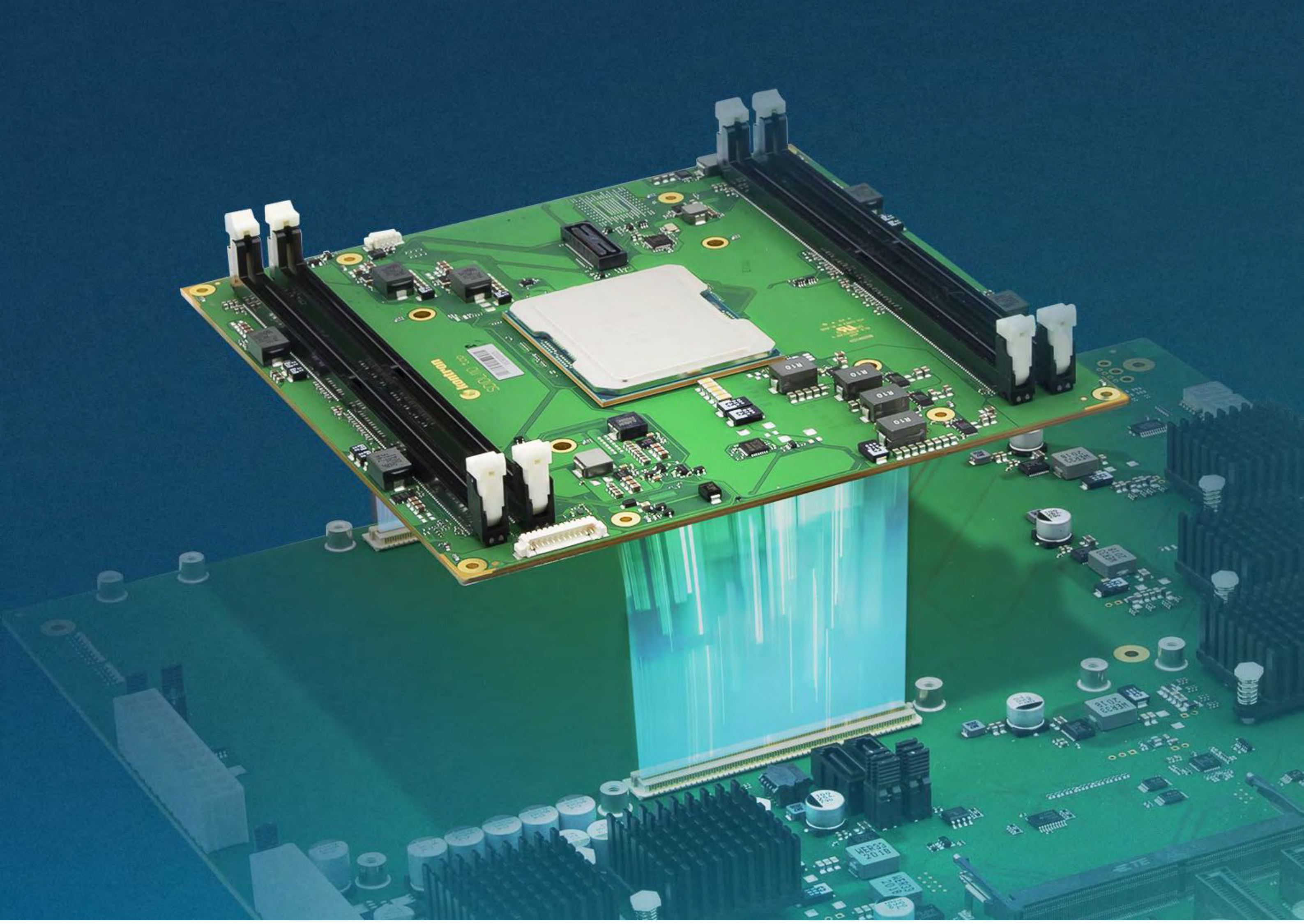
Typically, motherboards have six to eight PCB layers, making them more cost-effective than modules, which require more layers and additional comp

Modules also incur higher non-recurring engineering (NRE) costs due to extensive testing of assembled components. In contrast, motherboards are pre-tested against a range of specifications such as temperature, shock, vibration, and IP compliance, ensuring reliability without additional costs.

Summary of Benefits

- **Lower Initial Cost**
  More affordable than modules and carrier boards.
- **No NRE Costs**
  Eliminates design, production, and testing expenses.
- **High-Volume Benefits**
  Shorter lead times, better quality, easier maintenance.
- **Lifecycle Management**
  Enhanced by standardized support.
- **Product maintenance**
  Regular BIOS updates

When the project requires a customized BIOS and/or manageability tools, they are readily available from Kontron, a motherboard vendor with production facilities in Germany. This localization ensures exemption from specific regional tariffs that may be imposed for production in Asia. Localized production also helps avoid problems with supply chains due to political disruptions, counterfeit components, and other weather-related supply chain disruptions. The bottom line is that when you work with Kontron, you're dealing with a reliable and trustworthy source.



What is a Computer-on-Module (COM)?

A COM contains some but only a few elements housed on a motherboard. While the motherboard comes with a fixed I/O on one board, the COM is a two-board solution (module and carrier board) with customized I/O to meet the specific application's needs.

Its most important component is the CPU, which varies depending on the needs of the intended application. Other functionality, including various physical interfaces, is housed on a carrier board, and a board-to-board connector plugs in the COM. The module routes the necessary functional features through that connector, which physically mates with the carrier board. Those other functions could be processing, memory, storage, and various I/O interfaces.

COMe mini
55 x 84 mm

COMe compact
95 x 95 mm

COMe basic
95 x 125 mm

Deeper Dive into COMs

The PCI Industrial Computer Manufacturers Group, better known as PICMG, standardizes various module form factors. Within its popular COM Express® (COMe) specification, system engineers have three common form factors to choose from: COMe mini (55 by 84 mm), COMe compact (95 by 95 mm), COMe basic (95 by 125 mm).

Each COMe form factor offers a predefined pin-out configuration, varying performance levels, power efficiency, and I/O capabilities.

SMARC® (Smart Mobility Architecture) is a small form factor module that targets applications requiring lower-power, using an MXM-style connector to facilitate the module-to-carrier-board connection. They come in 82 by 50 mm or 82mm x 80mm. The Standardization Group for Embedded Technologies (SGET) standardizes SMARC®.

Finally, there's the newer, higher performing COM-HPC® modules, which have six distinct form factors across three module families: Client modules (Types A, B, and C measuring 95, 120, or 160 by 120 mm, respectively) addressing high-end embedded applications requiring one or more displays; server modules (Types D and E measuring 160 by 160 mm and 160 by 200 mm) for headless, high-bandwidth processing applications; and the new Mini form-factor, measuring 95 by 70 mm and providing a smaller footprint and less power for demanding rugged and mobile applications. Kontron is developing the COM-HPC® mini with 14th Generation Intel™ technology.

COMe is more closely associated with the x86 architecture, whereas the arm-based processor cores are usually in the SMARC® family. The SMARC® pin-out can also accommodate x86 compute platforms if needed.

Kontron's powerful COM-HPC / Server and COM-HPC / Client Modules

Watch video

Benefits of Using Computer-on-Modules

This modular approach enables flexibility and scalability in embedded system design, allowing developers to easily upgrade or customize their systems by swapping out modules without redesigning the entire hardware platform.

By adhering to industry standards, developers are assured compatibility between different modules and carrier boards, simplifying the development process and reducing time to market. In the end, module implementation may cost more initially but total cost of ownership (TCO) is lower.

Summary of Benefits

- **Flexibility**
  Easily upgrade and customize systems.
- **Compatibility**
  Ensures module and carrier board fit.
- **Simplified Development**
  Quicker time to market.
- **Cost Efficiency**
  Lowers overall ownership costs

The Decision-Making Process

Now that we understand the differences between the two options, how do you determine which is best for a given application? That question is best answered by answering a different question: where do you want to get to, or what is your end application?

However, even those questions lead to other questions, as some designs are improvements on existing designs (rather than being built from scratch), some require an upgrade path and multiple options within a product family, and so on. The best way to proceed is to look at real-world applications and considerations.

Comparative Analysis

Category	Motherboards	Modules
Technical Specifications	Fixed CPU, memory, storage, and I/O interfaces	Flexible CPU choices, scalable memory and storage, customizable I/O through carrier board
Environmental Adaptability	Designed for stable, controlled environments; rugged versions less common.	Wide range of rugged options suitable for harsh environments, with customization through the carrier board
Cost/TCO	Lower initial cost but potential for higher long-term costs due to upgrades	Higher initial cost, lower long-term costs due to modular upgrades
Upgrade Paths	Requires replacing the entire board	Module replacement allows for easier upgrades
Compatibility and Standardization	Adheres to standards (e.g., ATX, microATX, Mini-ITX) for system compatibility	Follows COM standards (e.g., COM Express®, SMARC®, COM-HPC®) for compatibility with carrier boards
Design Flexibility	Limited to the manufacturer's layout and features	High flexibility with the ability to design custom carrier boards tailored to specific needs
Time to Market	Quicker for standard applications due to off-the-shelf availability	Potentially longer due to custom carrier board design, but potentially mitigated by off-the-shelf options
Power Efficiency	Varies widely, generally optimized for performance	Can be optimized for low power consumption, allowing for more efficient power management
Support and Lifecycle	Varies by manufacturer, with industrial-grade offering longer support	Typically, longer lifecycle support, crucial for applications requiring long-term availability and support

The Decision-Making Process

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Medical

Industrial

Defence

AI

Transportation

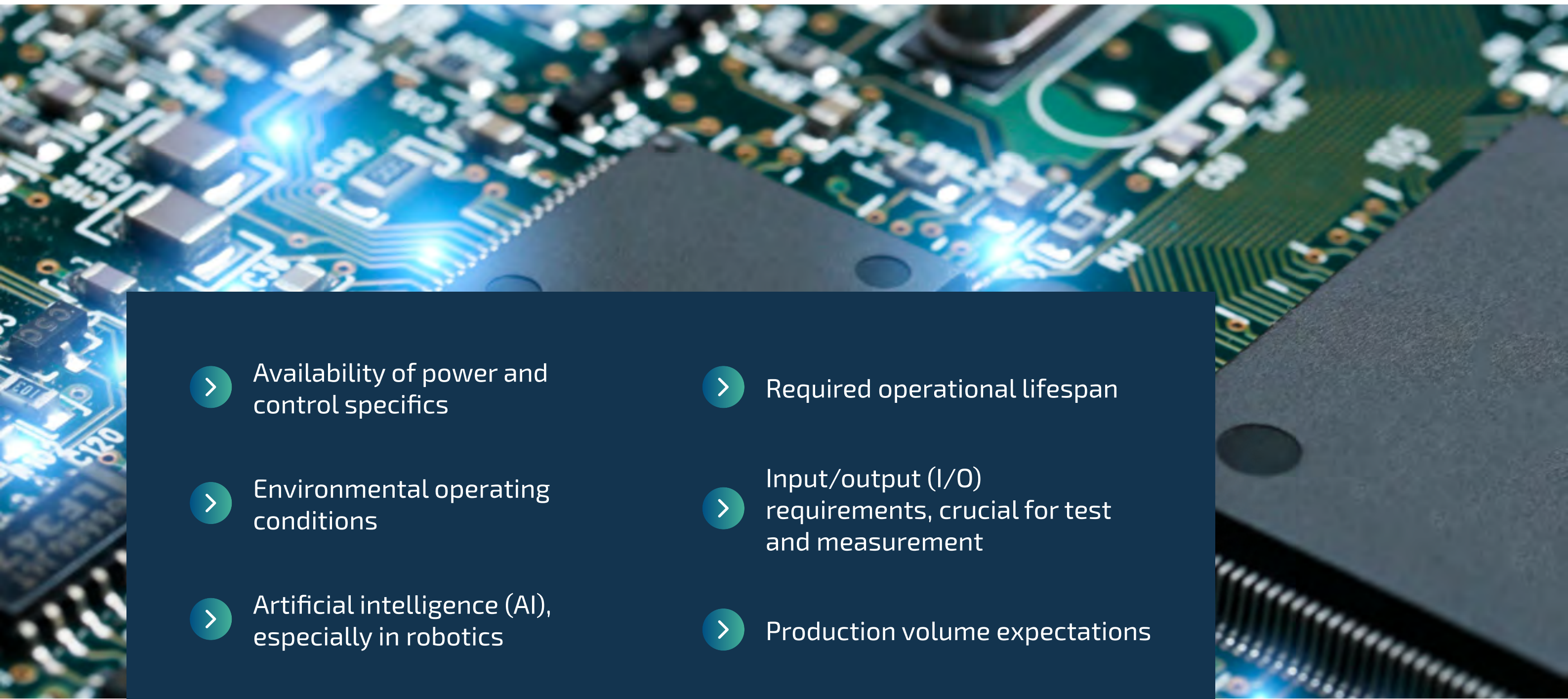
Space

Real-World Applications and Considerations

The selection of a computing solution significantly influences the performance and practicality of applications across various sectors, including but not limited to industrial automation and healthcare. Modules offer unparalleled modularity and durability for robust and dynamic settings, making them perfect for demanding industrial and external environments.

Conversely, with their comprehensive, unified architecture, motherboards are better suited to consistent, more controlled environments.

When targeting industrial applications, which constitute a significant sector, the critical questions include:



- Availability of power and control specifics
- Environmental operating conditions
- Artificial intelligence (AI), especially in robotics
- Space limitations
- Required operational lifespan
- Input/output (I/O) requirements, crucial for test and measurement
- Production volume expectations
- Time-to-market importance

Now, let's walk through some of the responses to the earlier questions. If ruggedness is near (or at) the top of the priority list, you should consider using a COM. A COMe board will be smaller and more rigid than a motherboard, meaning it can withstand higher levels of shock and vibration.

It's generally anchored to the carrier board, and if necessary, the SO-DIMM memory modules can be physically soldered to the board to create a very robust solution.

Power Considerations

Power can be a crucial criterion. Unfortunately, it is often only considered later in the design process, sometimes resulting in a redesign. Power closely relates to heat, and excessive heat can be problematic. It could require fans, which impacts the system's noise level. Note that fans also represent a potential failure point.

From a straight performance perspective, we typically look at the host microprocessor, whether it's in the x86 or Arm family. While there are certainly exceptions, the lower power parts tend to come from the Arm variants, while the more compute-intensive options hail from Intel® (and AMD). The Arm-based processors also tend to be less costly.

Product Longevity

The question about product longevity is an easier one to answer. Replacing an older module-based CPU is relatively simple. Just plug in a new module and ensure all the drivers are up to date. With a motherboard-based design, that's a more complex procedure.

Product Volumes

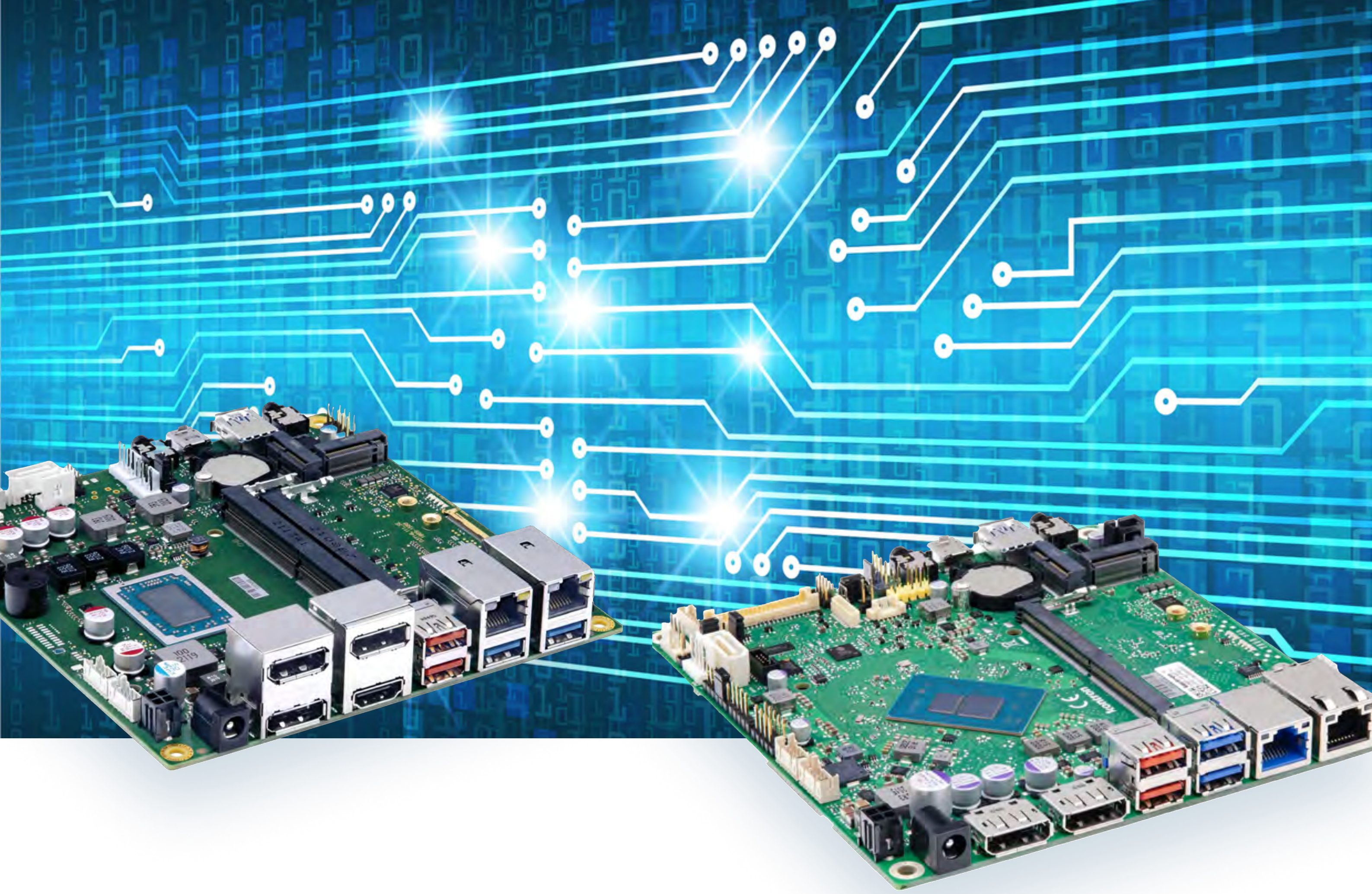
Companies often design and build their own modules or motherboards when annual demands exceed 10,000 units and they have sufficient resources. However, the need for quick market entry and limited resources typically drives them to purchase established solutions, allowing them to focus on their unique selling points without being tied to high production volumes.

Requirements for Medical

What is paramount for medical applications is security, the performance needed to drive imaging applications, and potentially AI. Certifications and approvals may also be required. Form factor is likely to be a priority, as well as low power. If the platform is in a surgical theatre, noise is a concern, and cooling fans add additional sounds. Most operating rooms strive to maintain sound levels below 68 dB to ensure maximum focus for medical personnel.

Operating System

If the choice of an operating system (OS) is high on your list, you can immediately narrow down your microprocessor choices, as specific OSs run better on certain microprocessors. For example, x86 is synonymous with Windows, while Arm-based CPUs tend to run some form of Linux. VxWorks and QNX Neutrino are also viable options for certain verticals and applications. Kontron also now offers Windows IoT licensing to maximize security, efficiency, and longevity for applications.



Motherboards That Make the Grade

By addressing these considerations, you can provide a comprehensive framework for selecting your specific application's most suitable computing platform, ensuring performance, efficiency, and adaptability.

Now you know what decisions are required. Regardless of your choices, Kontron has the necessary expertise and provides world-class products to help you select the optimal embedded board approach. Suppose you decide that a motherboard is suitable for your product. In that case, Kontron has a wide range, including the K3833-Q mITX. Thanks to its extended temperature range and ability to operate 24/7/365, it's geared toward industrial applications. It's equipped with the Intel® Q670E chipset and offers many supporting processors, such as Intel's Core i9/i7/i5/i3 (12th, 13th, and 14th Gen) and Pentium/Celeron processor series. All Kontron motherboards are manufactured in Germany, ensuring they are not subject to potential tariffs or delays caused by political issues or environmental factors. This guarantees consistent production and reliable delivery times.

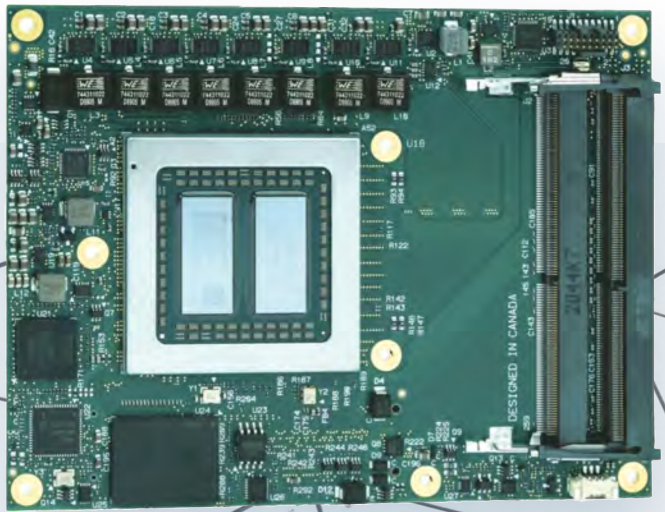
Another example is the K3921-H/Nx mSTX motherboard. The board features the Intel® Atom Alder Lake-N series N50, N97, N200, and i3-N305 microprocessors. In addition to its excellent graphics performance, the board has 2.5 GbE and enhanced TPM 2.0 security/encryption support, all required for any connected (aka IoT) application, including industrial automation, retail, smart cities, and healthcare. Other features include up to 32 Gbytes of DDR5 SO-DIMM memory, multi-USB ports, and audio output.

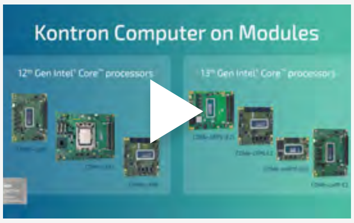
More than Capable COMs

If a COM turns out to be the best choice, Kontron has you covered there as well, with technology leadership and an unmatched breadth of products. That would include the server-grade COM Express® module COMe-bEP7, based on the AMD EPYC 3000 series of processors. The COMe-bEP7 is cost-efficient for applications requiring high processing power, such as medical imaging and servers. The COMe-bEP7 can scale in performance with up to 16 cores. It supports optional four SODIMM sockets with up to 128 Gbytes of memory and four 10-Gbit/s Ethernet ports.

Another great option in module form is the new COM-HPC® COMh-caRP, which is based on Intel's 13th Gen Core processors (previously codename Raptor Lake U/P/H), deploying 14 to 24 cores with Intel's performance hybrid architecture. The module provides essential, industrial-grade features such as in-band error-correction code (IBECC) memory support, Intel time-coordinated computing (TCC), TSN, and extended temperature ranges of -40°C to +85°C.

Keep in mind that some applications demand a custom product. If that's the case for you, that's also an option with Kontron. The company was founded in 1959 and has been at the forefront of embedded computing ever since. It is a founding member of the PICMG consortium that developed the original COMe specification and continues to offer expertise in subsequent generations. Kontron also provides leadership in other consortia, including SGET, the standardization body behind SMARC, the form factor that generally plays in applications that require low power, low costs, and high performance.





Kontron COM Express and COM-HPC Modules based on 13th & 12th Gen Intel Core Processors

Watch video

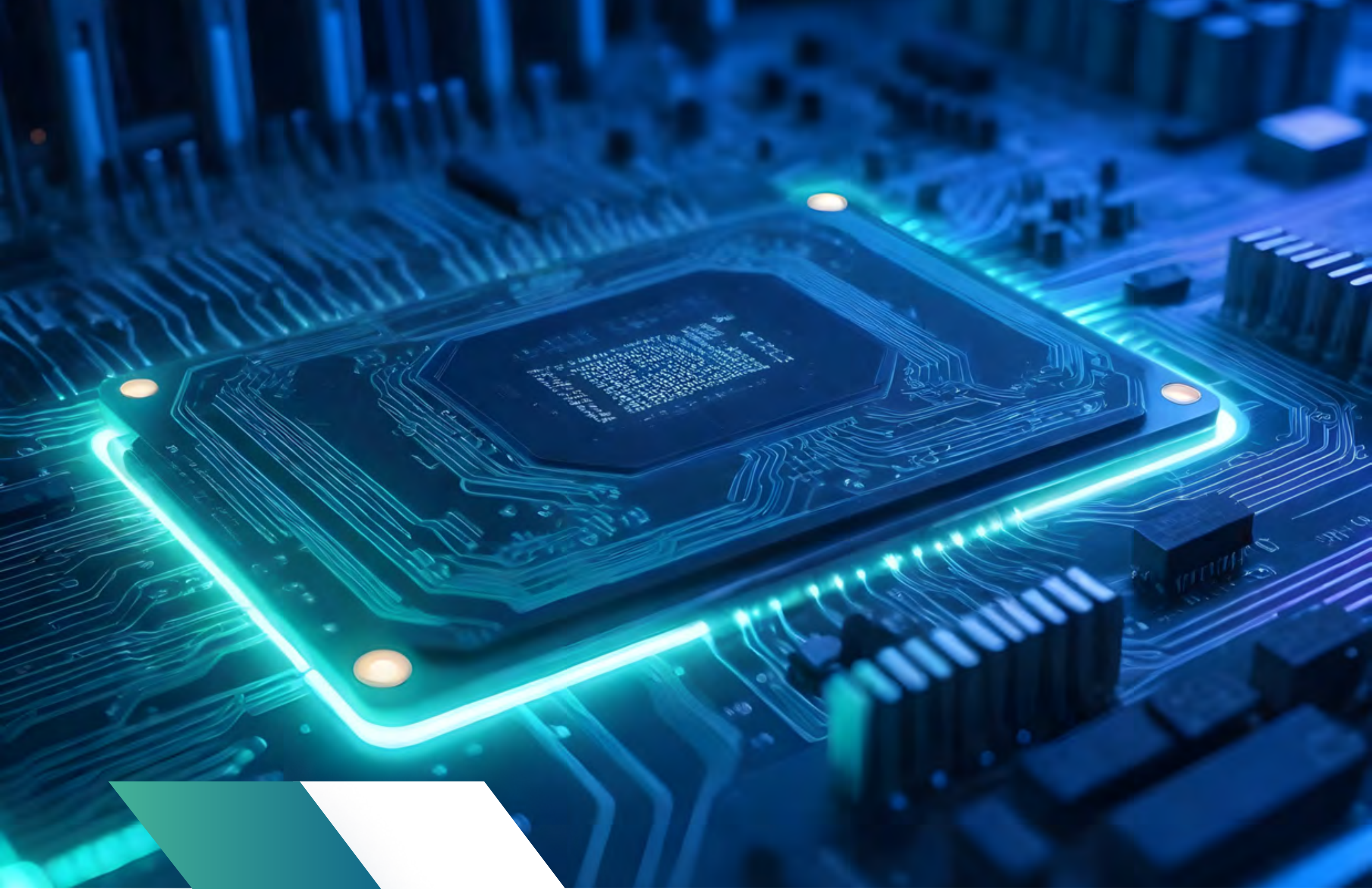
Making the Decision

Choosing the right embedded computing platform is a complex but crucial step in the development process. By understanding the unique benefits and considerations of motherboards and COMs, developers can make informed decisions that align with their project's needs, ensuring success in today's competitive market.

Some embedded computer developers also want to offer products with varying performance levels, say entry-level, mid-level, and high-end. The motherboard or COMe module can support different performance levels depending on the initial design.

Note that scalability goes beyond the performance of the CPU. From a system perspective, it has a lot to do with being able to upgrade/downgrade the characteristics of the application within a product family. For example, a standard carrier board can be used across an entire product family in a test-and-measurement application. Still, the engineer can turn off certain I/O features depending on the supplier's desires.

One decision engineers don't have to make is whether to enable security on their designs. The security discussion doesn't really lend itself to motherboards versus modules; it's more about choosing the right embedded computer partner. For example, all Kontron products come designed with integrated security features, including the company's Secureguard®, Secureboot, and TPM.



Conclusion

The goal of this whitepaper was not to sway you toward a motherboard or a module but to give you the information needed to make an informed decision on your own. From Kontron's perspective, they can support your needs either way. Kontron supports developers with a wide range of motherboards and COMs, offering unparalleled support, customization capabilities, and a commitment to product longevity.

Whether your application demands the robustness and flexibility of COMs or the simplicity and integration of a motherboard, Kontron has the expertise to bring your project to fruition. For more information, contact Kontron.

Kontron – Your Partner for Individual IoT Solutions

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About Kontron

Kontron is a global leader in IoT embedded computing technology, offering individual IoT solutions through a combined portfolio of hardware, software, and services. Kontron provides secure and innovative applications that benefit customers in various industries with fast time to market, low total cost of ownership, and extended product life cycles. www.kontron.com

About the Intel® Partner Alliance

intel partner Titanium

From modular components to market-ready systems, Intel and the over 1,000+ global member companies of the Intel® Partner Alliance provide scalable, interoperable solutions that accelerate the deployment of intelligent devices and end-to-end analytics. Close collaboration with Intel and each other enables Alliance members to innovate with the latest IoT technologies, helping developers deliver first-in-market solutions.

Learn more about Kontron's comprehensive module offerings

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Explore Kontron's innovative motherboard technology

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Discover Kontron's new software option

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Kontron America Inc.

www.kontron.com

9477 Waples Street
San Diego, CA 92121, USA

+1 888 294 4558

info.americas@kontron.com

Global Headquarters Kontron Europe GmbH

www.kontron.com

Gutenbergstraße 2 85737
Ismaning, Germany

+49 821 4086-0

info@kontron.com