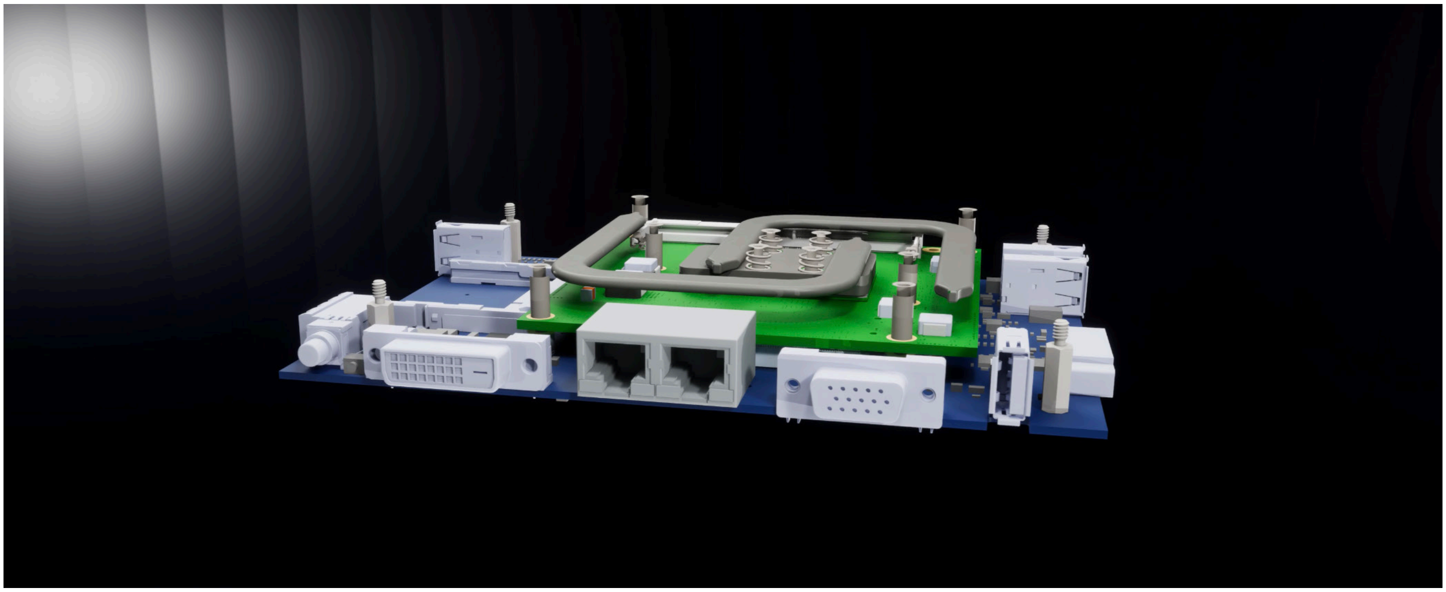
New Product Introduction: 5 Proven Strategies for Rapid NPI



Introduction

New product introduction (NPI) presents a wide set of challenges for engineers and manufacturers. More specifically, NPIs for embedded computing and critical communications products introduce known challenges related to time, costs, and risks – compounded by recent disruptions to the global supply chain. There are several key strategies to mitigate these challenged and expedite NPIs:

- Leveraging scalable, flexible technology
- Refining and improving performance with cutting-edge design techniques
- Engineering thermal solutions
- Capitalizing on IP and integration before, during, and after product developments
- Employing parallelism and controlling known supply chain variables

Leveraging Scalable, Flexible Technology

Embedded computers are an integral part of a larger device or system – as opposed to a standalone desktop computer – and generally perform a highly specific function. There are several different approaches to and architectures for embedded computing; one of the most flexible and scalable options is COM Express.

COM Express

COM Express is a family of modular, small-form-factor computer-on-module (COM) specifications defined by the PCI Industrial Computer Manufacturers Group (PICMG). COM Express architecture is a two-board system, consisting of an off-the-shelf computer module combined with an application-specific carrier board to address the unique I/O requirements of the application.

The COM module provides the system with the high-speed computing functions that are common to most applications including the CPU, memory, graphics, Ethernet and USB communications, SSD interface, and expansion buses. By leveraging the more standardized computing functions provided by the COM module, engineers can focus on the design of the carrier board to address the unique I/O requirements and to meet the mechanical footprint of the application.

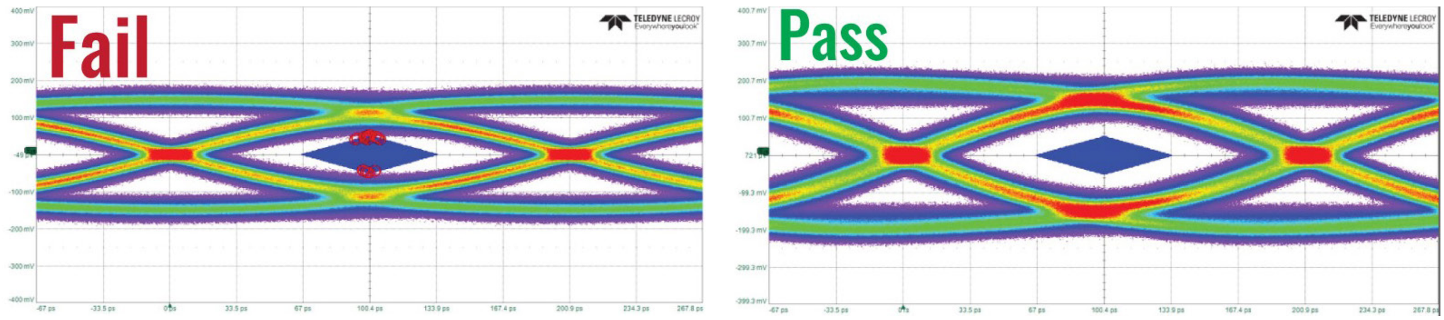
Utilizing a COM Express and carrier board architecture has three major benefits for NPI:

- **Easy upgrades** - Individual components can be replaced without an entire system redesign. New technologies or hardware components can be added to the system without significant redesign or re-engineering.
- **Shorter time-to-market** – The modularity of the platform allows designers and engineers to focus on developing the core functionality of the system without overemphasis on the underlying hardware, accelerating the development process.
- **Greater flexibility** – The modular design of COM Express allows designers and engineers to select and combine individual modules to create custom hardware configurations. This helps meet specific application requirements and optimizes system performance, as well as any SWaP-C2 requirements.

Refining & Improving Performance with Cutting-Edge Design Techniques

Throughout the design process, diagnostic software and specialized equipment are used to identify areas for improvement and design optimizations to maximize the product's overall performance.

Using specialized software, extensive simulations are performed to refine the performance and signal integrity of printed circuit board (PCB) early in the design process. These robust evaluations encourage early design optimization which leads to improved pass rates for initial prototypes, reducing the number of revisions. The data generated by these tests are displayed graphically, enabling engineers to quickly assess performance and quality to troubleshoot the design.

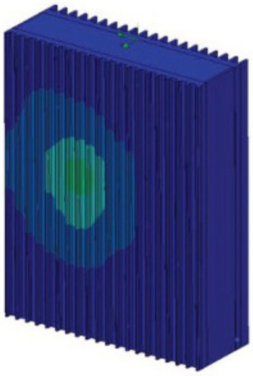


Example of an oscilloscope output.

Once prototypes are produced, digital signal analyzers are used to test and analyze signal voltages, frequency, amplitude, intervals, and distortion. The above eye plot was generated using these digital signal analyzers. These analyzers test the high-speed buses that are prevalent in embedded computing design, such as USB4, 10 Gigabit Ethernet and Gen 3 and 4 PCIe.

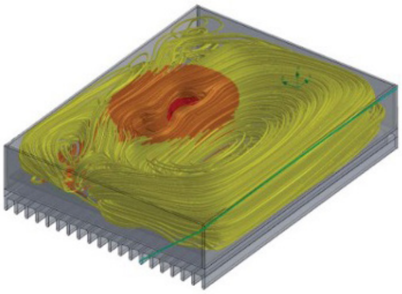
Engineering Thermal Solutions

In applications where external thermal conditions cannot be controlled, engineers must design devices with minimal heat production. Prototype thermal simulation and testing expedite the process and reduce overall costs. Design refinements can then be made to improve performance prior to sending the device for official lab testing and certification.



Minimizing, Conducting, & Simulating Heat

Once the required operating temperature is defined, each component should be evaluated and selected to meet the temperature range requirement. Component conduction can be optimized using fine surface finishes to encourage more efficient connections, reducing thermal energy. For circuit placement and design, reducing the proximity between heat-producing components allows you to avoid hot spots and magnify heat dissipation. Examining other equipment that will be part of the overall system is also vital as this equipment can not only produce additional heat but reduce airflow.



Example of heat modeling software output

Fans are a common solution to mitigate heat and improve airflow, but they often have the effect of increasing both the cost and complexity while introducing another opportunity for failure. In industrial, mission-critical operations, fanless and solid-state designs are preferred to ensure reliable performance. For example, heat sinks work by absorbing heat from the central processing unit or the graphics processing unit. As these components are primary heat producers, it is vital to keep them cool and mitigate heat as the risk of failure increases with more heat generation.

When designing for temperature extremes, the exterior body should be assembled with the fewest parts possible. Minimizing the locking points of the enclosure reduces thermal resistance which allows energy to escape the system and ultimately improves heat conduction. Machining processes allow for creative designs that are used to further draw heat away from the system components. For example, a series of fins can be arranged along the device or rods can be extended from the enclosure.

Thermal Testing

Once components and materials are chosen, a prototype is created, and component placement and product testing ensue. Components must be placed strategically to avoid hot spot creation from heat generation.

The ability to complete prototype testing and thermal simulation within the original manufacturing facility expedites the process and reduces overall costs. Additionally, at this phase, adjustments to thermal pad types and materials can be evaluated for optimal heat dissipation.

Capitalizing on IP & Integration Before, During, And After Product Development

Incorporating firmware from an established IP library allows engineers to dramatically reduce the development time of new and/or custom products. Further, common pitfalls associated with firmware development can be avoided.

Firmware for Design & Debug

Firmware is low-level software that is embedded directly into a hardware device. The actual code – depending on the device this is usually some combination of C, Assembly, Java, and/or Python – is stored and run from read-only memory (ROM) chips soldered to the hardware. Firmware provides the basic control and management functions for hardware components. Simply put, firmware allows hardware devices to communicate with other hardware devices and high-level software.

At the onset of NPI, firmware is critical as it allows for the intentional reuse of code, dramatically improving time to market. By incorporating proven firmware from a library of IP, scheduling can be condensed, and resources can be utilized more efficiently. Proper firmware planning is important. Planning and architecting the firmware in the early phases of development can save priceless time later in the project.

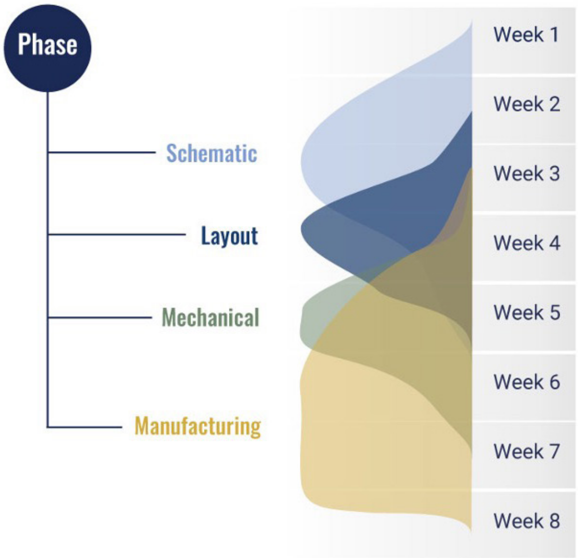
Another key factor is the ability to test firmware. If there is a problem in the development phase, it is easy to get to the root of the issue, ensuring that when the product is deployed, it operates as intended every time. Because the firmware is an integral part of the device, it can be modified to assist with debug as well, providing specialized clues of what is happening between two complex parts of the system.

Reliable, intentional firmware also has the benefit of building in the capability to upgrade a device in the field, allowing you to fix any holes or gaps and to add new features. In many cases, it is possible to incorporate features like remote access into firmware, allowing users to push upgrades or fixes over a network without the need to pull units from the field.

Employing Parallelism and Controlling Known Supply Chain Variables

There are four major stages of the design process: schematic, layout, mechanical, and manufacturing. In traditional serial design scheduling, each of these stages are undertaken in a sequential order, with each phase being completed before moving to the next phase.

Parallelism, on the other hand, enables these four development processes to proceed in parallel. This results in shorter project development timelines and early detection and mitigation of flaws. Incorporating all the teams involved in product design and NPI as early as possible leads to significant benefits and makes the entire process much more efficient. Further, supply chain variables can be addressed during each of the development processes.



Typical development schedule utilizing parallelism

Schematic

The schematic stage is one of the first stages in the design process, and involves the initial, abstract conceptualization of the product. Following parallelism methodology, the schematic stage is a good time to first engage with the procurement and manufacturing teams. Collaboration with the procurement team allows for more thorough "second sourcing," which can better inform R&D of preferred components. Including in-house manufacturing and testing teams is beneficial as it facilitates early planning for specific test points, product functionality testing, and overall product reliability.

Layout

During this stage, the layout of all the various components of the product is determined, and early prototyping occurs. PCB layout engineers work closely with production teams to ensure DFM – Design for Manufacturability – which dramatically reduces the potential for production errors and increases efficiency by optimizing the overall design and component placement. Frequently, initial prototypes are manufactured in-house during this stage to refine both the manufacturing processes involved in the new product, as well as to begin product testing.

Mechanical

Mechanical design commences shortly after layout begins. At Sealevel, this stage includes engaging metal fabrication partners to develop a clear understanding of the physical capabilities and tolerances to ensure the overall mechanical design is attainable. Early feedback on enclosure design from production and build teams improves the efficiency and ultimately product quality.

Manufacturing

Perhaps the greatest benefits of the parallelism methodology are realized in the manufacturing stage. Firstly, the early inclusion of the manufacturing team allows for a gradual refinement of the manufacturing processes and practices for the new product. Throughout the entire NPI process, the production and build teams have direct access to quality managers to improve the product-build process to continually refine and improve for increased efficiency. Finally, including the manufacturing team early allows them a more nuanced view of the supply chain concerning the new product; having a fuller understanding of the product allows the organization to better respond to any supply chain issues.

Conclusion

NPI for embedded computing and critical communications products presents a wide set of challenges for engineers and manufacturers. There are several strategies to mitigate these challenges.

Leveraging scalable, flexible technology is achieved through the use of COM devices. Modular systems like COM Express are advantageous for NPI in several ways. The COM module provides the computing components, while an off-the-shelf or custom carrier board provides all of the required I/O components. COM modules have a long lifecycle – up to 15 years – and the modularity of the platform allows for easy upgrading.

Refining and improving performance with cutting-edge design techniques is achieved through the use of specialized technology and software. Specifically, extensive simulations are performed to refine the performance and signal integrity of PCBs early in the design process. Once prototypes are produced, digital signal analyzers are used to test and analyze signal voltages, frequency, amplitude, intervals, and distortion.

Thermal engineering thermal solutions must be employed in applications where external thermal conditions cannot be controlled. In these cases, engineers must design devices with minimal heat production. Prototype thermal simulation and testing expedite the process and reduce overall costs. Design refinements can then be made to improve performance prior to official testing and certification.

Capitalizing on IP and integration before, during, and after product development includes incorporating firmware from an established IP library allows engineers to dramatically reduce the development time of new and/or custom products. Further, common pitfalls associated with firmware development can be avoided.

Finally, employing parallelism and controlling known supply chain variables is critical in NPI. Simply put, an approach incorporating parallelism allows the discrete steps of serial design scheduling to proceed in parallel. This approach results in shorter project development timelines and early detection and mitigation of flaws, by incorporating all the teams involved in product design and NPI as early as possible.

Sealevel's approach to NPI, as outlined above, has been developed and refined through decades of experience managing product development. By leveraging COM architecture, Sealevel is able to achieve future-proof technology, long product lifecycles, and SWaP-C2 optimization. Sealevel has designed and manufactured over 100,000 embedded computing solutions since 1994 for customers in defense, public safety, wind energy, oil and gas, and industrial automation. Our more than 35 years as a leader in I/O and communications products allow us to design and manufacture custom carrier boards and full system solutions in the fastest time possible.

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