WIND™

It's Transformation Time for Embedded Development

New Technologies Are Changing Old Practices Fast

WHEN IT MATTERS, IT RUNS ON WIND RIVER

EXECUTIVE SUMMARY

Fast-evolving technologies including virtualization, multi-core processors, and system-on-chips (SoCs) are bringing exciting new capabilities to embedded devices. These technologies can help address new market requirements such as Internet of Things connectivity, cloud computing, machine-to-machine (M2M) communications, and improved security, but they also underscore an uncomfortable truth: Development risks increase with new technology and requirements, yet not enough is done to address development risk early in a project. Finding, mitigating, and solving risks early are key to delivering a quality project on time and on budget.

Embedded development is now at a tipping point. Complexity, cost, risk, and delay are all on an upward climb, and each new technological advance and market shift only exacerbates development challenges. Development teams are under intense pressure to get their projects completed on time and to make them more future-proof and secure—without sacrificing features or quality, and while working with budgets that have already been cut.

Successful innovators are now turning to a new breed of solutions designed to handle escalating complexity across the embedded development lifecycle. Wind River® is helping companies transform and accelerate each stage of embedded development. Innovating faster, reducing risk and cost, and improving developer efficiency are key goals of this new approach—effectively shifting your development lifecycle timeline to the left. Using the Wind River portfolio of solutions, developers have transformed their processes to deliver on the promise of new embedded technologies—meeting new market requirements, on time and on budget. The "shift left" approach is all about transforming embedded development to meet the business and technology goals of the future.

This paper discusses how shifting left is transforming the way the world's most innovative embedded device manufacturers drive innovation across all phases of their embedded development lifecycle.

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NEW TECHNOLOGIES ARE NOW PERVASIVE …

The number of development projects involving new technologies, such as multi-core, multi-OS, hypervisor, and SoC, continues to rise. In fact, meta-trends such as cloud computing, M2M communications, and the Internet of Things are accelerating the adoption of virtualization; mobile telephony and burgeoning platforms such as Android are expanding SoC development. Even comparatively simple designs might include multiple processors, a mixture of CPU types, DSPs, ASICs, FPGAs, and other devices.

… BUT TRADITIONAL DEVELOPMENT PLATFORMS CAN'T DELIVER ON THE PROMISE ALONE

A paltry 14% of "new technology" projects are counted as successful today, according to studies from Invent/Vermont, and fully a quarter of multi-core embedded design projects miss their deadlines and their functional targets by at least 50%, according to Embedded Market Forecasters. Following are just a few examples of why current approaches and practices aren't cutting it:

- **Legacy embedded software platforms aren't meeting security and compliance requirements:** New technologies introduce more technical and business risk to your product development. Much of this risk is unknown at the early phases of development, so scheduling and cost estimation is difficult. In highly regulated markets such as healthcare, aerospace and defense, and telecom, the cost of non-compliance or a breach of regulation can be crippling—but as devices and applications become more capable, the risk for transgression increases. Developers need to discover and deal with risks earlier in the lifecycle.
- **In-house and roll-your-own tools, operating systems, and middleware weren't designed for the new technologies and aren't keeping up:** More and more device functionality is delivered via software, and developers are struggling to integrate legacy tools and processes with new tools and techniques. Hardware sophistication is also mushrooming: in the embedded world, many products now use 32-bit and 64-bit multiprocessor architectures, and multi-core versions of processors further complicate development and testing. Yet hardware and software can no longer be developed independently; the "system" has become the highest level of abstraction, which means device manufacturers need a way to drive system definition, development, and deployment in very collaborative and iterative ways. It's just too expensive and risky to upgrade and maintain in-house solutions when commercial off-the-shelf (COTS) software solutions offer better support for new technology and market demands. And it doesn't make sense for development teams to spend time and effort on embedded operating system platforms when differentiating and revenue-generating features are at risk. Commercial solutions offer a lower total cost of ownership than roll-your-own (RYO) solutions.
- **Many software development tools don't provide vital capabilities:** Tools for multi-core, virtualization, and SoC development must deliver new capabilities that legacy development tools simply don't provide. Developers need to be able to find issues with parallelism, performance, and cache coherency quickly; they must address challenges around configuration and prototyping; they must support diagnosis, analysis, and testing. Simply put, new technologies add more "multiples" to be managed at every phase of development, and teams are already pressed to make deadlines with projects involving older technologies.
- **Concentrate on product features, not maintaining product platforms:** Many embedded development teams spend a significant portion of their development on developing and maintaining software platforms that are either RYO operating systems and middleware, or open source solutions that the team is supporting themselves. Embedded developers need to spend more time on money-making features, not RYO solutions. When trying to create more features using smaller budgets, it makes sense to let commercial companies replace RYO solutions.

> "With Wind River VxWorks multi-core solution, we were able to deliver our product on time and reduce the risk of development."
>
> —Dr. Ralf Koeppe, Vice President, Research and Development, KUKA

> "Wind River Linux has made development much easier and faster. We are able to save 20 to 30 percent in development time using Wind River Linux and tools. Along with our internal enhancements, our entire product lifecycle has significantly improved."
>
> —Yossi Bar-Sheshet, Director, Software, Corrigent

SHIFTING YOUR EMBEDDED DEVELOPMENT LIFECYCLE LEFT

Every project starts with a vision—a goal for a product that is truly remarkable. Achieving that vision requires an orchestration of internal and external variables at each phase of development, in a way that maximizes quality, mitigates risk, minimizes complexity, reduces overall cost, and ensures timely completion of the project.

The shift left approach can help you realize your project's vision. Discovering risks earlier in the lifecycle reduces their impact later in the lifecycle, avoiding the "big bang" integration effort that derails many projects. You'll accelerate key activities within the five key phases of embedded system development, allowing your teams to complete projects faster without compromising on features, quality, or security.

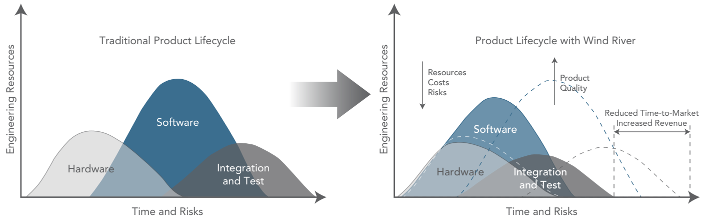

Figure 1. Shifting your embedded development lifecycle left with Wind River

PHASES IN SOFTWARE DEVELOPMENT LIFECYCLES

This paper does not attempt to define or redefine the software development lifecycle; the phases below are discussed in general terms about the various stages of development a project goes through. Neither does this section imply a waterfall development methodology, nor discount an iterative or agile one.

1. Define Phase

During the define phase the project vision, candidate architectures, and new technology are documented, analyzed, and explored. This phase might include, for example, resolving issues such as how to provide network connectivity to a medical instrument, how to consolidate multiple services into a single chip, or how to reduce complexity in a transportation safety system.

Risks

The impact of risks in the define phase is large since early decisions made at this point impact the rest of the project. For example, choosing poor architecture or an underpowered hardware platform, or not accounting for security features, will cause a huge disruption when discovered (often too late) later in the project. This phase is a good time in which to consider mentoring, open source strategies, design services, and COTS platforms to reduce the additional risk of a RYO solution.

Design, Mentoring, and Thought Leadership

Wind River has experience in many vertical markets and can provide expertise for your architectural decisions at this critical point, including consideration of new and innovative approaches such as full system simulation, system consolidation with multi-core technologies, and platform solution approaches that can accelerate the entire product lifecycle.

Platform Solutions

Next-generation products can leapfrog from concept to reality using pre-built platform solutions. Wind River offers a proven platform on which to base a new product, comprising embedded OS run-time, tools, and middleware. These platform solutions allow development teams to concentrate on differentiating features rather than operating system and middleware development, maintenance, and testing. Platform solutions are the accelerators to really boost development efficiency. Their role in the define phase is critical since architecture decisions are being made and commercial solutions considered.

> "With Wind River, we achieved a robust off-the-shelf foundation featuring OS agnosticism; safety and security solutions; and pre-integrated, industry specific platforms with a rich set of middleware. In addition, Wind River offers an ISV partner ecosystem and services practice that help us speed up, build out, and customize our solutions."
>
> —Martin Greif, Head of R&D and Automation Units, Bachmann

Full System Simulation

During the define phase, full system simulation reduces risk by allowing hardware and software teams to collaborate from the beginning of the project, exposing underlying assumptions to the broader team, and creating assets and artifacts that drive collaboration downstream across teams.

Wind River Simics® is a full system simulator that simulates target hardware, from a single processor to large, complex, and connected electronic systems. It enables the target software (BSP, firmware, real-time OS, middleware, and application) to run on a virtual platform the same way it does on the physical hardware—it is fast and functionally accurate.

Using traditional hardware-based approaches, it may take system architects weeks, months, or even years to determine optimal system configuration—and they often omit the critical step of performing an analysis using the legacy software, which adds risk to the architectural analysis. But using Simics, developers can answer the fundamental questions much faster by using more "what-if" scenarios. They have no need to redesign hardware, purchase and solder parts, apply power, and then network everything. Instead, they can simply use Simics to quickly redefine the number of processors on each board, the number of boards, the type of board, and so on. These new custom virtual platforms can be quickly networked together, and real software can be executed and evaluated.

> "The Wind River solution enables us to enhance product features and increase our productivity. We've been able to accomplish all this while staying on budget"
>
> —Lutz Kersten, Department Manager, R&D Surgical Therapy Software, Olympus

2. Bring-up Phase

The initial project vision first materializes during the bring-up phase. The hardware and operating system are booted, with initial configuration and stability as top concerns.

Risks

Unique to embedded development, this phase is where developers configure and integrate operating systems, board support packages, and hardware. The risk during this phase is that integration takes too long due to unforeseen defects in hardware and software and the lack of availability of reference hardware. This phase happens in parallel with development and can often slip too late in the process. In addition, discovering software platform issues at this stage can ripple through the entire project. Risk can be mitigated by using COTS solutions with associated engineering services to shorten the time to productivity on new hardware. System simulation brings ubiquitous and early access to the hardware.

Board Support Engineering

The hardware bring-up and platform setup and test phases, unique to embedded development, are significant enough to warrant their own phase. Development teams can spend too much critical time and resources on in-house board support code, operating systems, and tools. COTS offerings provide proven platforms to accelerate the bring-up phase. Critical to these offerings are board support engineering services to customize and optimize the commercial operating systems to the device's unique hardware design. Doing this work in-house increases costs and risks, and doesn't result in product features that make money.

Wind River and its partner ecosystem offer the largest database of existing board support packages for VxWorks® and Linux, and expert customization services to accelerate the time to productive development.

Operating System Platforms

The system bring-up phase can be extremely time-consuming for RYO solutions. A team is needed to build and maintain the operating platform, but also the board support for the various target systems you plan to deploy. COTS solutions with broad hardware support greatly reduce the risk and cost at this stage. Wind River, with its broad partner network and large BSP library as well as its embedded OS platforms, is well poised to accelerate board bring-up.

System and Board-Level Simulation

It's commonplace in embedded development that your product target platform simply isn't ready or even available yet from your hardware vendor. Simics provides full system and board-level simulation for even the most sophisticated hardware platforms. Early and ubiquitous access to your target platform pays huge dividends in productivity during this critical hardware bring-up phase. Reduce the bug-fix timeframe from months to days or even hours.

Debug and Development Tools

As development teams validate their designs—or simulated environments—against actual hardware, they need efficient ways to identify and resolve system-level bugs and perform optimization on both the software and hardware architectures. Wind River products, including Wind River Workbench and Simics, are tightly integrated with VxWorks and Wind River Linux operating systems, enabling efficient automation across a range of system analysis, compiling, and debugging tasks.

With Wind River engineering services, tools, and operating environments, development teams can bring up, debug, and stabilize heterogeneous hardware, software, and systems fast; automate across a range of system analysis, compiling, and debugging tasks; accelerate defect resolution; and ensure that modified or customized boards conform to the same quality standards and performance benchmarks as their reference designs.

3. Develop Phase

During the develop phase, the applications that will bring the initial project vision to life are developed.

Risks

This phase encompasses the full-out development and unit (even subsystem) testing of code for the project. Developer efficiency is key during this phase, as getting the most bug-free code implemented on time is the primary goal. Risks here can include difficulty with new technology such as multi-core, poor or no tools to help with debugging, embedded OS issues that take away from time on new features, and lack of access to hardware resources.

Mentoring and Training

The development phase is where the serious coding takes place. Wind River can train your team on the tools and operating systems they are using. Training tailored to the specific needs of your project reduces the time needed for developers to explore and experiment with new technologies. Appropriate training, design services, product support, and mentoring accelerate the entire team's productivity.

> "Working with Wind River has allowed us to reduce our overall new product development cycle time. In addition, using Wind River Professional Services has allowed us to augment our engineering staff with Wind River staff . This allows our people to focus on market-specific applications, which results in accelerating our total time to market."
>
> —Richard Kephart, Director
> of Research and Technology,
> Emerson Process Management

Ubiquitous Access to Target Hardware

Simics provides access to the target platform for the entire team. No more booking lab time to test your software; developers can have their own virtual platform. This access to embedded target hardware greatly reduces developer wait time, so they can spend more time coding and testing and get more features done. Equally important is the super-powered debugging that is possible with full system simulation. Bugs can be traced back in time to find the source, and detailed system state information is available, as is full control of the execution of your application.

Wind River also offers virtual labs with remote access to hardware, and provides expertise and intellectual property such as prebuilt stacks and certifications for market-specific platforms that short-circuit development time and help customers get to market on time and on budget.

> By using Wind River Simics, 80–90% of the simulation models can be reused for other missions, representing tremendous cost savings for NASA.

Scalable, Secure, and Safe Operating System Platforms

COTS solution stacks offer greater flexibility and scalability than custom-built, RYO solutions. In the development phase, being able to reuse subsystems within families of products is a huge productivity booster. Embedded solutions that already provide much of the needed OS and middleware capabilities provide the ideal starting point for product family development. Wind River solution platforms are scalable from small power-efficient devices to large scale, multi-core, multi-board systems. Having one vendor, a common toolset, and a familiar and proven operating environment cuts risk, costs, and time-to-market.

Integrated and Optimized Development Tools

The quality of the output from previous phases has a direct impact on how efficiently development teams move through the development phase. Using Wind River Workbench tools ensures high-quality, well-validated inputs to this phase. Wind River Diab Compiler, the most reliable and mature compiler in the industry, has a proven track record for generating robust, compact, and fast-executing code for thousands of designs and millions of devices, and is widely used in mission-critical applications such as automotive under-the-hood, industrial, and aerospace and defense systems.

4. Integrate Phase

During the integrate phase, the system components are integrated and the system is tested against the initial vision. Risks of delay surface most often during this phase, and power, performance, and footprint become key.

Risks

Integration is often where many of the missteps of the early phases of development are felt. For example, misunderstood or missing requirements might be discovered, or a chosen hardware platform might turn out to have insufficient processing power, or new technology might break legacy software. The key to mitigating risk in this phase (in fact, the key to mitigating risk from the beginning) is to discover the issues earlier rather than later. This is the fundamental concept of "shift left:" transforming embedded development by leveraging COTS solutions that improve the risk profile of embedded development.

Leverage COTS Solutions

The integration phase is often when things break, and when you find critical architectural issues in large complex systems. Relying on a proven platform with pre-integrated operating systems, tools, and middleware reduces the amount of integration and testing required for a significant portion of your new product. Instead, your team is integrating and testing the differentiated features that will make your product most competitive.

> "Functionality, reliability, and localized support were the key factors we considered—and Wind River VxWorks was the right answer. With the commercial-grade solution from Wind River, we have dramatically increased our development efficiencies, reduced engineering costs, improved time-to-market, and assured product quality."
>
> —Barry Xue, Director,
> Base Platform Department,
> Corporate Software Department,
> Huawei

Early Integration for Bigger Risk Reduction

The benefits of Simics also extend to the system integration process. Once the basic operating system and software layers are up and running on a virtual platform, system integration and testing can begin. With Simics, this means integration testing can start very early in a project—long before hardware or a complete software stack exists. User applications can be developed for the first iterations of an operating system and integrated with other applications, legacy code, and third-party binaries on a virtual platform early in the development cycle.

With Simics, system integration can begin solely on virtual platforms, expanding to a combination of virtual and physical hardware, and finally to fully physical hardware as those models, software, and hardware elements become available. Throughout the process, the same toolchain used on physical hardware can be used. Because integration is performed so much earlier in the development process compared to traditional hardware-based approaches, the "integration" moves from a single high-risk task that begins largely after all hardware is delivered to a much lower-risk activity that progresses in parallel with both software and hardware development—that is, continuous integration.

5. Sustain Phase

During the sustain phase the system is kept working and relevant for end users, in line with the initial vision, through hardware and software updates, in-field diagnostics, training, and support.

Risks

In embedded systems this post-deployment, in-service phase is a unique challenge due to long lifespans for products. In addition, embedded devices are often harder to update and manage. The risk at this stage is that decisions in the product development phases have led to a higher total cost of ownership for the product line. Risks and costs can be reduced at this phase by relying on commercial solutions that offer long term commitments to products, with support and solutions that provide a much lower cost of ownership than custom or RYO solutions.

Long Term Maintenance and Support

In this phase—after release of the application or device—Wind River products and services remain a valuable asset. Simics, for example, can be used in several ways in the sustain phase, including for encapsulation of customer-specific configurations, for setting up a virtual lab to assist with customer support, or even as a platform for delivering training programs. Simics makes it possible to prepare course scenarios in the form of checkpoints; if users manage to break or misconfigure a system, resetting to a clean state is easy because Simics does not save state changes unless specifically told to. Fault injection and scripting can be used to set up training scenarios for users to handle.

Wind River also offers a range of support services for the sustain phase. For example, Wind River Premium Project Support provides a dedicated resource to set up labs for sustaining engineering tasks. Wind River can also provide sustaining engineering resources. In addition, the company's success in harnessing offshore development means resources are readily available to cope with demand, helping to lower the cost of executing patches and maintenance releases.

> "With so little time available, any delays or difficulties would have been disastrous. Responsive, efficient technical support allowed our project to go full speed ahead, without any stops or delays."
>
> —Riccardo De Filippi, Head of Development, Magneti Marelli Motorsport

THE SOLUTION PORTFOLIO TO TRANSFORM YOUR EMBEDDED DEVELOPMENT

Wind River offers a broad set of products, solutions, and services to embedded development teams. In order to truly transform the way you develop products now, you need a solution set that augments the embedded operating system with tools and services. Adopting a proven commercial approach enables early discovery of risks and improved mitigation of these risks throughout development. Embedded transformation is about moving risk discovery early in the lifecycle and reducing the overall risk with proven COTS products. This approach means that you can count on Wind River in all phases of a product lifecycle and for the lifetime of the product. Figure 2 shows how each product or service family supports each phase of development.

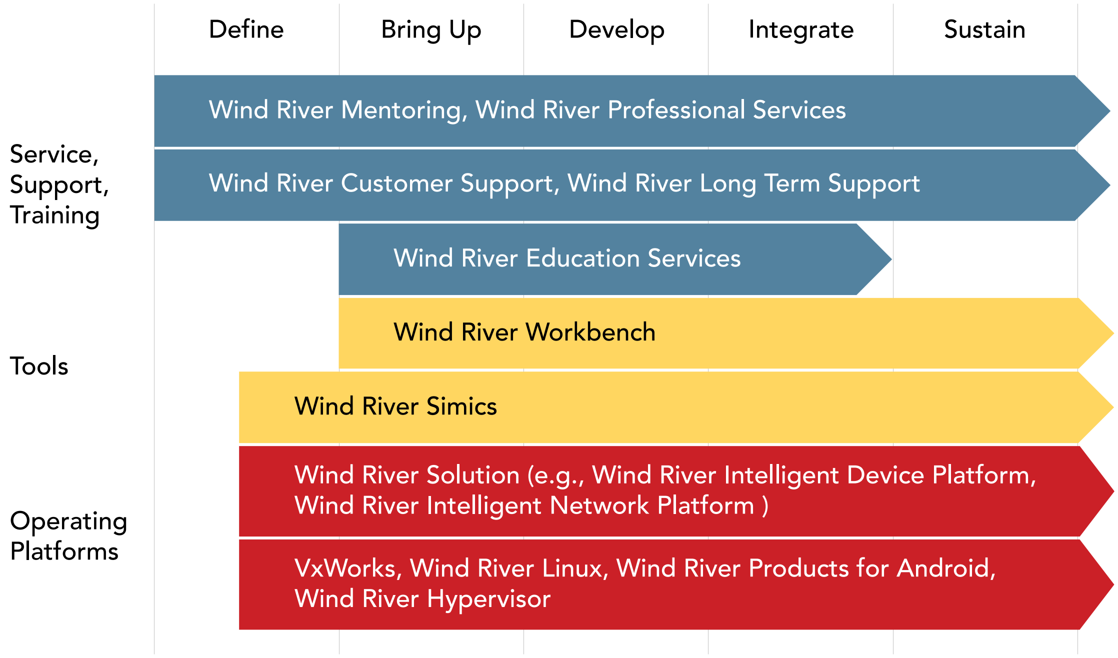
Define
Bring Up
Develop
Integrate
Sustain
Service, Support, Training
Wind River Mentoring, Wind River Professional Services
Wind River Customer Support, Wind River Long Term Support
Wind River Education Services
Tools
Wind River Workbench
Wind River Simics
Operating Platforms
Wind River Solution (e.g., Wind River Intelligent Device Platform, Wind River Intelligent Network Platform)
VxWorks, Wind River Linux, Wind River Products for Android, Wind River Hypervisor

Figure 2. Wind River portfolio and development phases

CONCLUSION

Why have so many companies accepted business as usual in embedded development for so many years? Why haven't they adopted new platforms, tools, and processes to fully exploit the advantages of new technologies such as multi-core, multi-OS, virtualization, and SoC?

Because until now, there hasn't been a choice.

For companies that are interested in transforming embedded development from a headache into a true competitive advantage and a source of differentiation, the Wind River solutions portfolio is an exciting advance. It is a proven portfolio of integrated technologies; it accelerates the development process at every phase of the lifecycle; and it is complemented by outstanding service and support offerings from Wind River and its ecosystem of partners.

Learn more about how Wind River can solve the challenges of today's embedded development projects. Contact us at 800-545-9463 or visit www.windriver.com.

Wind River is a global leader in delivering software for the Internet of Things. The company's technology is found in more than 2 billion devices, backed by world-class professional services and customer support. Wind River delivers the software and expertise that enable the innovation and deployment of safe, secure, and reliable intelligent systems.