Developing competitive products
Executive Brief
July 2009

Rational. software

Turning product development into competitive advantage.

Best practices for developing smarter products

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Executive summary

Smarter products. You hear them mentioned in trade journals, in boardrooms and in the press releases of your competitors. What are smarter products? How do you make them? And how do you make them better and faster than your competition?

The purpose of this paper is to explore smarter products and discover some best practices that businesses can employ to build smarter products and drive innovative technologies, such as:

- *Employ a holistic design process that includes requirements management and traceability through all engineering disciplines*
- *Become value driven and continually assess how to optimize your products, services and projects*
- *Understand your product in the context of a system*
- *Provide all business disciplines across your enterprise with a single, shared view of all product requirements*
- *Perform extensive modeling early in the development process and use it to evaluate the impact of changes across the entire system*

Whether you operate in the automotive, aerospace, telecommunications or electronics marketplace, business trends dictate that you need to deliver innovative products that incorporate advances in software, electronics and hardware to deliver a customizable experience to users. The key to creating this new class of offerings is to elevate software development to a strategic business process while leveraging advanced modeling capabilities to better integrate your different design disciplines.

What are smarter products?

As you exit your driveway, your car sends a signal to your home to arm the alarm system while your cell phone automatically synchronizes with your car's voice command system. Having analyzed your recent driving patterns, the vehicle's global positioning system (GPS) recommends a new route to cut fuel costs and avoid traffic delays. Finally, the car informs you that your antilock brakes need servicing and, after checking the schedule on your personal digital assistant (PDA), presents you with available appointment times.

Smarter products are …

… instrumented

The potential of products is taking off with the incorporation of new technologies (for example, sensors, actuators, cameras and GPS systems) that provide individualized context and let you measure, sense and see the exact condition of just about everything.

… interconnected

Mass production no longer dictates how people use specific products. Instead, when a collection of smarter products is interconnected into an ecosystem to work together, it creates experiences that can mold to the specific preferences of an individual's daily work and personal life.

… intelligent

The array of products used to deliver an experience can now get to know you or the problem you are trying to address. It can respond to change quickly and accurately and get better results by predicting and optimizing for future events.

This example is just the tip of the iceberg. Businesses around the world are looking to revolutionize mundane tasks and daily activities with innovative technologies. They are beginning to see products not as solitary solutions, but rather as components of a greater system—one that can be adapted to fit the personality of each individual user or business. How? Manufacturers are tapping into innovations in software, microelectronics, actuators, sensors and mechanical technology and fusing these advances into a portfolio of "smarter products" supported by open standards in ways not previously possible. These "smarter products" are increasingly intelligent; realtime instrumented; and interconnected to other products, the Internet and relevant back-end IT systems.

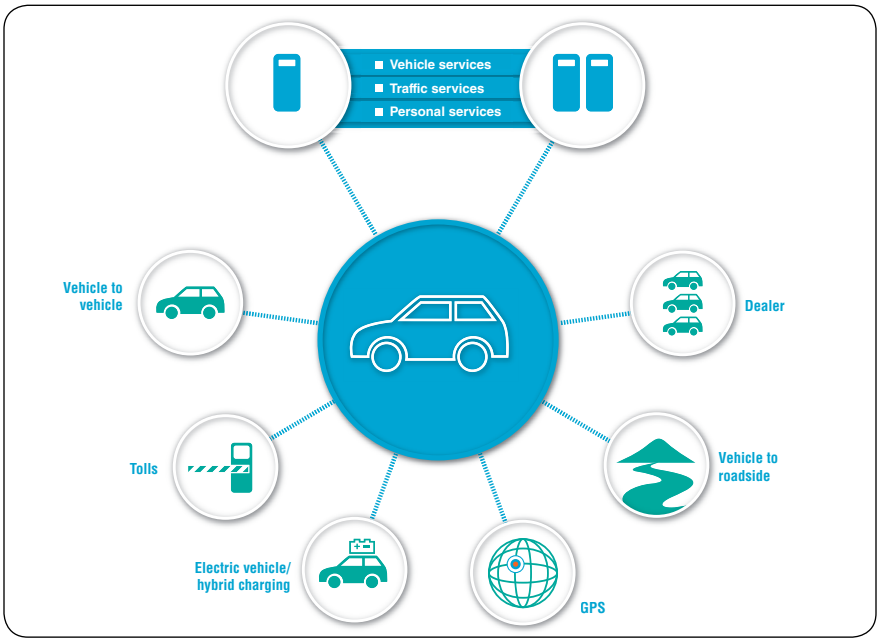

Figure 1: Smarter products are extremely pervasive and demand a level of intelligence and integration previously unheard of.

A new layer of complexity

Because smarter products are more complex, they require a new paradigm in how they are designed, created and evolved. Just consider the challenges inherent in designing and building smarter cars[1]:

- *The operation of modern, premium vehicles now requires dozens of microprocessors running 100 million lines of code, compared to a U.S. Air Force frontline jet fighter, requiring 1.7 million lines of software code.*
- *Half of car warranty costs are related to embedded electronics and software, costing automakers in the United States around US$350 and European automakers €250 per car.*
- *Software and electronics costs can reach up to 40 percent of the cost for a modern car; the software alone represents roughly a US$1 billion investment in some cases.*
- *In a premium car, there are 2,000 to 3,000 independent functions related to software, which are rolled into the 250 to 300 functions used by the driver and passengers.*

Why smarter products? Differentiation

The six billion people on the planet all have unique needs, desires, hopes and approaches to getting things done and enjoying life. However, manufacturers are quickly realizing that individuality—the desired experience—can differentiate their offerings. Businesses and consumers are now craving personalization and integration of the products they rely on every day—products that understand the context of what they are doing and can adapt to help deliver results. This demand for smarter products is driving manufacturers and service providers to look for new, innovative ways to differentiate their products.

The nature of smarter products

Marketplace factors such as customer satisfaction are driving the trend toward smarter products, and to deliver, businesses are being forced to rethink the very nature of their products. Simply put, smarter products demand more from manufacturers that want to deliver a new experience to consumers. And these demands present themselves in a number of ways.

Systems of systems

As if designing and building complicated systems weren't hard enough, many of today's products, such as cars and planes are, in fact, systems of systems. Features are no longer isolated within individual products and are instead delivered through integration with back-office business processes. For example, in-vehicle security system vendors can now provide emergency services and can alert first responders with accident details gathered using vehicle sensors and passed through the vehicle's security system to assess the severity of automobile crashes.

Shrinking product lifecycles

Consumers seem more demanding today than ever. Not only do they want the smartest product—they also want it now. And before you know it, they're looking for an upgrade. As a result, the service life for many products, especially electronics, is shrinking, forcing manufacturers to prioritize features over quality.

These same consumer demands are leading to shrinking development times, but *fast to market* may not necessarily mean *right to market*. Moreover, marketplace windows for specific capabilities are shrinking, making hitting a window of opportunity a significant challenge.

Crash telemetry technology

OnStar, by General Motors, is an automated crash telemetry service that contacts emergency call centers in the event of a vehicle crash. Impact sensors communicate with the onboard OnStar system, which connects with the OnStar call center and finally the 911 emergency system. This telemetry service can greatly increase the chances of driver and passenger survival.

The technology has proved itself in real-world situations: A driver of an OnStar-equipped vehicle was injured in a car crash. The vehicle reported the change in velocity (impact force) to an OnStar operator, who then communicated that information to first responders. Based on this knowledge, the 911 operators were able to dispatch the most appropriate rescue resources sooner.

Mechanical aspects are becoming commoditized as product value shifts to software

Today, the hardware that previously differentiated products has largely become a commodity, and it is becoming increasingly difficult to differentiate products based on electronics alone. Only a few years ago, an MP3 player was just that—a device that played MP3s. Now MP3 players must not only play music but also host music libraries, stream video, run applications, support messaging and offer games. And devices that cannot be easily updated with new functionality quickly become obsolete, destined for a local recycling center.

Manufacturer or software company? The blurring line

The reality is that product manufacturers are now also becoming software companies, infusing the technological capabilities of electrical, mechanical and software components into a new generation of innovation. Unfortunately, many companies simply do not have the skill sets, resources or development platforms necessary to build and integrate the intelligent software that is needed.

Traditionally, software and hardware development teams have worked independently, but as new software-driven product functionalities take shape, the two disciplines need to evolve together to provide a high-quality working component. This is easier said than done because changes may affect components across multiple teams, leading to complex project management, testing and change control.

Hydraulic hybrid delivery vehicles

Eaton Corporation developed hydraulic hybrid delivery vehicles featuring innovative technology for urban delivery trucks in stop-and-go traffic. These next-generation hydraulic hybrid vehicles have a combination of mechanical, hydraulic and electrical systems orchestrated by software to act as a single integrated system.

The hybrid delivery vehicles have embedded smart software to optimize energy usage and reduce greenhouse gases. As a result, companies such as UPS have reduced carbon dioxide ($C0_2$) emissions by 40 percent and achieved a 60 to 70 percent reduction in fuel consumption, according to the Environmental Protection Agency.

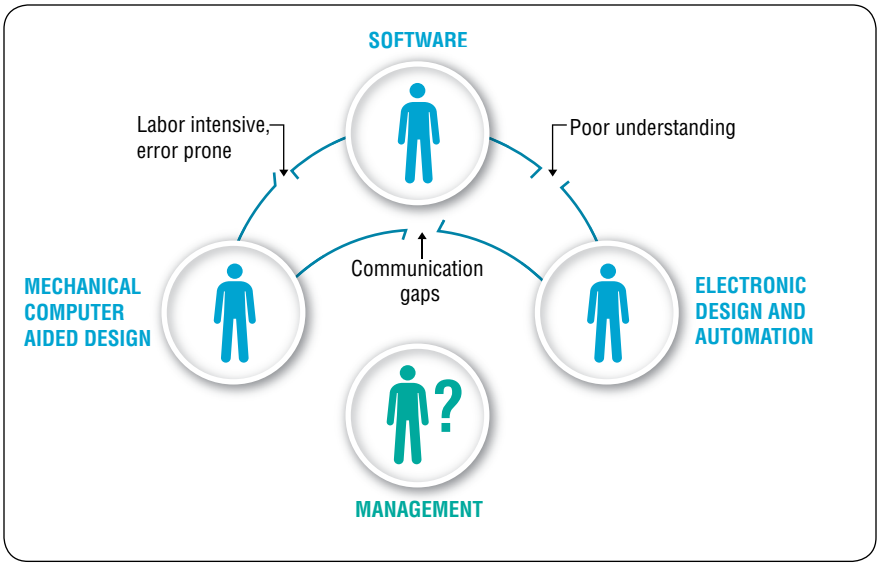

Figure 2: The gaps that exist between vertical development silos can undermine project visibility, reaction to change and requirements mapping.

To develop smarter products, companies must also ensure that their products interconnect with the Internet and back-end IT systems. They must learn how to develop products that can talk together within their intended ecosystems using standardized communication protocols to break down the traditional silos between IT and systems, between competing companies, between vendors and between governments.

An encompassing view

Understanding how the smarter products fit in context of their ecosystems can offer businesses:

- *Better understanding of overall system requirements and constraints.*
- *Help in the design process by focusing on the interaction of the system with the surrounding environment.*
- *Aid in avoiding errors through explicit design and architectural decisions that, when left implicit, are often the cause of errors.*

Implications of an inefficient approach

Failure to adapt to the new challenges for building and delivering smarter products can significantly affect a company's bottom line and brand image. The speed of innovation in today's world means that organizations must evolve now to remain competitive tomorrow. The risks of inaction are significant:

- *Loss of marketshare leadership to more nimble organizations that can effectively innovate to meet marketplace demands and respond to competitive threats*
- *Loss of revenue and profit from the inability to develop complex products in a shorter cycle without compromising quality*
- *Increased development and customer service costs resulting from identifying problems toward the end of the design cycle*

Best practices for developing smarter products

As we've seen, remaining competitive in the current marketplace requires significant changes in the way value is delivered in today's products. And this value, in turn, is driving changes in the way these products are built—from a focus purely on cost to a focus on innovation with software as a major differentiator. Business drivers are shifting from departmental productivity improvement to globalized development. And the product development process itself is evolving from a focus on three-dimensional (3D) computer-aided design (CAD) and mechanical bill-of-material (BOM) management to the design of a holistic system—one that includes requirements management and traceability through all engineering disciplines, including mechanical, electrical and software.

In fact, an Aberdeen Group study shows that those companies whose products include more software in the product mix do better than those whose products are more mechanical or electronic.[2] But to deliver smarter products, companies must focus on software development within an enterprise-level systems engineering approach. Moreover, because practically no product these days exists in isolation, companies need to manage the systems of systems that compose the overall ecosystem within which the product will exist.

ABB

ABB is a designer of power and automation technologies for a wide range of utility and industry customers. With such a diverse customer base, the business needed to be able to accurately capture the key product requirements of each market segment. Deploying a new multidimensional analysis tool, the organization can now identify the features and capabilities considered to be most important for the marketplace and subsequently prioritize design requirements to create more marketable products.

Decide what, when and how

The first questions to ask when building smarter products are what to build, when to release it to the marketplace and how best to deliver required functionality.

Portfolio management

The product portfolio decisions you make today will determine whether your company is still relevant tomorrow. With such a fine line between success and failure, companies must make product portfolio decisions based on fact—not guesswork, political agendas, intuition or the opinions of the loudest voice in the room.

Considering its importance, portfolio management is ironically one of the weakest areas of new-product development. Only 25 percent of businesses effectively rank and prioritize their projects, with only 21 percent of portfolios containing projects that are of high value to the organization. And fewer than 20 percent of companies have the right balance of projects in their development portfolios.[3] Added to these facts, 76 percent of businesses have too many projects for the resources available, and only 21 percent have a portfolio management system in place to help them select their best projects.[4]

To increase the chances of marketing a successful product, organizations must become value driven. Benchmark analysis indicates that companies that are best in class at portfolio management are four times more likely to achieve margin advantages of 75 percent or higher for products on the market for less than two years.[5] Becoming value driven requires a continual assessment of how value can be increased through the optimization of the products, services and projects that your organization delivers.

Mobile access to medical images

Merge Healthcare provides its medical professionals with reliable, secure access to complex medical images and reports via mobile devices. Having these images available at any time from anywhere helps ensure prompt emergency diagnosis.

By enabling healthcare professions to review images on the go, Merge Healthcare has reduced its hospital operations costs. IBM Rational® solutions embedded in the mobile systems facilitate collaboration across globally distributed development teams, as well as change management across the end-to-end software lifecycle.

Product management

Proper management of the portfolio can have a dramatic effect on the value a company delivers to its customers. But management of the product itself is just as important. In fact, product managers are more frequently acting as the CEO of a product, bearing the responsibility for the strategic and tactical activities that help position a product in the marketplace and decide when to retire it.

Few things are more critical to the success of a company than its new-product launches, since many businesses notice higher margins on products that have been on the market for less than two years. However, product success is difficult to achieve as a large percentage if new-product launches fail.

A successful product delivers value to its customers and revenue to the business that creates it. But to ensure value and revenue, product managers must define their target customer segment and understand its needs. To develop a product that delivers value in relation to the cost of development, product managers must also understand the value of different product features to different customers. By providing the right features to the right group of customers at the right time, a product can create value and revenue.

Westinghouse Rail Systems Australia

Marketing its rail signaling and control solutions across southeast Asia, Westinghouse Rail Systems Australia (WRSA) needed to design its offerings to comply with a number of global and national safety and reliability standards. As an added complication, the business had to deliver technology innovations that were backwards compatible with previous equipment, as few customers wished to update their entire rail signal infrastructure.

WRSA deployed a uniform requirements and configuration management solution that enables designers from across the company (regardless of location) to move seamlessly between projects without interrupting development schedules. Moreover, the business can leverage this design flexibility to more easily tailor its offerings to support the unique needs of each region in which its solutions are sold.

Ensure that customer requirements are met

To maximize the chances of success, companies need to ensure that smarter products deliver the specific capabilities defined not only by customers and the overall marketplace but also by how the product will operate as a system. Understanding the product in the context of a system will produce a set of requirements that will determine what the system does and how it does it.

Before the online collaboration capabilities that exist in today's product development environments, business processes operated in isolation, with the only communication being formal handoffs from one process to the next. Based on its research, the marketing department would outline product features and functions and give those requirements to the design department. Designers would consider those requirements when creating the master design, which was routinely documented in two-dimensional (2D) drawings or 3D computer models.

Problems with this approach were twofold. First, the design engineers had to interpret the marketplace requirements because their functions—or the "why" behind the requirement—were rarely specified. For example, a marketplace requirement called for a cup holder in a car but without any specifications. The result: cars on the road today with cup holders that can't be easily reached, block access to the radio when in use, and sit above the dashboard computer, which is subjected to spilled beverages.

The second problem was, with the increase in software enabling smarter products, the means for satisfying requirements has dramatically changed—yet the means for communicating requirements has not. In the past, requirements for an MP3 player may have included volume control, implying the need for a volume button (hardware) and electronic volume controller (electronics). This

Delphi

Delphi, a leading global supplier of mobile electronics and transportation systems, wanted to automate requirements management to promote cost savings through component reuse among global development teams. The company enhanced team communication and collaboration to share requirements across different projects, saving time and money while accelerating time to market for new products.

requirement could be articulated in the product design by adding a document with the models for a volume button and underlying electronic components. However, today's requirements may call for user-defined volume curves, with both preset and user-defined equalization capabilities, all of which are supported by software. Thus, the requirements must be understood not at a document level, but at a statement level. Moreover, these requirements must be associated with specific system capabilities, rather than simply with software modules.

To design against requirements correctly, marketing must be able to specify the intent behind product functions and capabilities. By doing so, marketers can guide development decisions in advance, rather than as checkpoints after the design is complete. To avoid confusion and miscommunication, all business disciplines across the enterprise—engineering, quality assurance and internal legal teams, as well as other peripheral stakeholders such as suppliers and customers—should have a single, shared view of all product requirements. And finally, the requirements specification should provide a means of quality testing, with product testing being conducted against initial marketing needs.

Océ

A leading international provider of digital document management technology, Océ designs advanced software applications that deliver documents and data over internal networks and the Internet to printing systems and storage archives. Wanting to add the fastest cut-sheet printer in the world to its offerings portfolio, the business ran into a number of design challenges in developing a control system that could accurately track the dozens of sheets of paper that would be simultaneously running through the printer.

The business employed a model-driven development strategy to decompose the complex printing system into smaller, more easily designed subsystems. Moreover, by coupling the object orientation and inheritance features of model-driven development, Océ has been able to heavily promote component reuse within the new printing solution. This design strategy helps to shorten time to market, increase efficiency and improve overall quality.

Navigate complexity with modeling

The infrastructures required to support smarter products are typically complex, forcing businesses to pursue a modeling strategy that supports the entire system—not only the physical product but its connection with its environment: a systems of systems. By modeling the entire system early in the development process, businesses can simulate various product and architectural alternatives early in the development process when changes are much less expensive.

From these system models, businesses can perform trade studies to determine which design choices make the most sense and predict behaviors of the system and its structures. Having determined a set of behaviors, companies can create logical structures meant to support those behaviors and map product capabilities to specific parts of the system. This may require a variety of models to help with understanding of the system before the actual physical product is designed.

With an overall design of the system in place, a business can begin designing the component software, mechanical and electronic parts. The system model provides a synchronization point across these disciplines, allowing each to create its own set of models but then coordinating these through the system model.

The ability to model relationships between requirements statements and system-level capabilities (including, but not limited to, software capabilities) helps businesses:

- *Ensure that requirements (along with their intent) are met.*
- *Devise and automate tests for software development.*
- *Generate software code automatically to implement specific functionality.*

System modeling provides an abstraction mechanism that allows an understanding of the system as a whole, preventing situations in which the overwhelming system complexity can obscure the big picture. This allows architectural decisions to be made intentionally, not as an accident or afterthought, while providing a mechanism to ensure that the product addresses customer and marketplace requirements at all stages of development.

BAE Systems Australia

BAE Systems Australia is a designer of integrated military systems and support solutions for the Australian Defence Force. Previously, the organization had been unable to effectively coordinate the efforts of its hundreds of geographically dispersed developers, resulting in duplicated efforts. The business was unable to even establish corporate best practices for design staff since requirements management tools varied between teams and projects.

The organization implemented a unified requirements management solution to support requirements analysis on all customer projects, as well as proposals. Designers can now maximize requirement reuse across all phases of development, yielding faster bug resolution and shorter time to market.

Manage change

Despite the best design efforts, changes to a product design inevitably occur—marketplace dynamics shift and customers may develop different needs. Understanding the effect of a change within the design of today's smarter products can be challenging. In the past, finding which mechanical components were affected by a change to another mechanical component involved nothing more than simply traversing the product structure.

However, smarter products are much more complex, given that a change to a mechanical component can affect one or more electrical components, each of which, in turn, may be controlled by software. Just finding which elements are affected is complex enough, but the real key is understanding the significance of a change (identifying what modifications need to be made, determining the associated costs, balancing these costs against the benefit and ensuring that the product still addresses customer, marketplace, performance and quality requirements after the change is made).

Modeling provides a means to conduct trade-off analyses through simulation, assessing the effect of a change across the entire system within a huge network of complex interdependencies. System modeling also enables exploration of the effect a change could have throughout the distributed development team and the supply chain. For instance, a change may require using a part from a different supplier, which operates under a different contracting structure, meaning that the purchasing organization could be involved in the change process.

The key to successful change management is integration across engineering disciplines, tools and applications as well as back-office processes that touch on the product development process. With the ability to collaborate and share information, changes can be made more intelligently, with knowledge of the end result available at the time of the change—before the product is in the hands of the customer.

Philips Medical Systems

Philips Medical Systems is a producer of medical equipment, such as X-ray, ultrasound and nuclear medicine imaging equipment, as well as the related IT systems needed to support these devices. With a development team spanning three continents and a waterfall development approach, the business experienced great challenges when it needed to alter design plans to accommodate changes midway through a project.

The business shifted to an iterative development approach that employed established best practices as well as a number of integrated design tools intended to support geographically distributed development teams. Under its new design plan, Philips Medical Systems can more readily support multisite application designs and more quickly respond to changing priorities and business needs while delivering quality software systems with less risk and increased productivity.

Elevate software development to a strategic business initiative

Companies well versed in mechanical-engineering technologies have not necessarily adjusted to the increase in software content within their products. In particular, they have not adopted good software development methodologies.

Model-driven software development

Just like mechanical development, software development should be model driven. Using models, software engineers can more clearly analyze requirements, define design specifications, test systems concepts using simulation, and automatically generate code for direct deployment on the target hardware. Teams can improve productivity and reduce head count, standardize processes and automate repetitive tasks to improve team efficiency while reducing time to value and enhancing regulatory compliance through self-documenting data and workflows.

Using model-driven development, telecommunications companies have seen productivity improvements, including 46 percent fewer designs behind schedule and 49 percent fewer designs cancelled.[6] Similar to mechanical development, the results from model-based development are seen downstream from the development process in the form of fewer prototypes and physical mock-ups.

Collaboration enabled between development groups: increase visibility, remove silos

As software development has evolved from centrally located development facilities to globally distributed development, visibility of the activities of various teams has decreased. Walking down the hall to collaborate with a team member is no longer possible, given that a team member could be located across the country or across the world. Today's development teams must leverage Internet connectivity, as well as a unified software development platform, to establish virtual collocation.

A unified platform helps remove development silos by enabling the integration of applications and the sharing of knowledge as well as the sharing of project status through management dashboards. Software quality, in turn, is improved through less rework, better project tracking and higher team satisfaction. Based on IBM experience, developers can reduce wasted rework by 25 to 50 percent by collaborating on work items, defects and build errors.

Governance and measurement

An often-overlooked aspect of software development is the ability to measure and govern how well the process is performing. In fact, governance, not compute power, is routinely the key to higher productivity, helping to improve overall productivity. And when trying to improve software development, it's often helpful to use a four-step framework to measure capability improvement:

- *Phase 1: Elicit and set business value objectives.*
- *Phase 2: Determine the solution components.*
- *Phase 3: Accelerate and monitor solution adoption.*
- *Phase 4: Review and communicate business results.*

Using a measured capability improvement framework enables incremental, measured transformation of software delivery, accelerates adoption through out-of-the-box assets, provides flexible feedback on the business process and captures industry experiences in incremental adoption.

Toward a competitive advantage

In recent history, software development has become increasingly important in creating successful products and driving business results. And a holistic view of product development is critical to navigate the rapid changes in how value is delivered through smarter products. Businesses can no longer let products evolve or add capabilities as an afterthought. Instead they must be as rigorous in their software development efforts as they have been with any previous discipline, determining the effect of changes across departments, across companies and across IT ecosystems before making them. And in those efforts, IBM is leading the way in refining software development efforts for products to help you design and deliver the smarter products that your customers demand—before everyone else does.

For more information

To learn more about IBM Rational software and how it can help your company more efficiently deliver smarter products to the marketplace, contact your IBM sales representative or visit:

ibm.com/software/applications/plm/rational.html

Endnotes

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