Manufacturing innovation

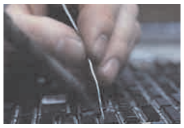
Reinventing the wheel of innovation… with a virtual product hub

Introduction

It has happened again. An unexpected rival just launched a competing product, and, in a matter of weeks, your product has become passe. Unfortunately, you are beginning to notice a trend. Competitors are consistently outmaneuvering you—with better marketing, outstanding quality or a superior look and feel. You can't quite move fast or far enough. Even more troubling, you aren't sure exactly why. Sound familiar?

No matter the duration of one's development cycle, the market continues to demand a shorter one. Manufacturers are searching for ways to spin the wheel of innovation ever faster—all the while increasing profits.

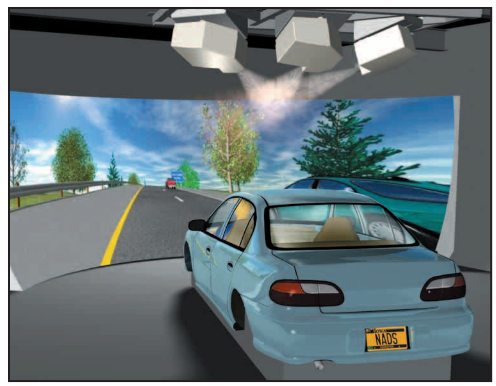
Based on research and analysis of leading automotive manufacturers around the world, IBM has identified several key practices that, when implemented together, can lead to world-class levels of product innovation. Although originally uncovered through analysis of heavy industrial manufacturing, these insights can be readily applied to almost any type of industry—from airplane to electronics manufacturing. While each of these practices involves a unique blend of people, processes and technology, all rely on a common capability to collaborate, integrate and innovate: *the pervasive use of a virtual product.*



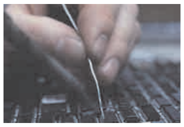
The virtual product

As the name implies, a virtual product is a completely digital product representation. It consists of a three-dimensional, geometric model, plus all supporting information required to actually manufacture the product – including non-visual characteristics such as speed, weight and cost.

For a number of years, manufacturers have relied on computer-aided design (CAD) software to produce electronic representations of their products and demonstrate design intent. Innovative companies have taken this practice a step further by electronically linking CAD systems with product data-management (PDM) systems — establishing a single platform that can be used across the enterprise and with key suppliers to facilitate simultaneous, collaborative design. Using digital mock-ups, these businesses evaluate alternative design concepts, perform multiple product tests and prepare manufacturing tools and processes — without having to build, test and subsequently destroy a large number of expensive physical prototypes. Ship builders, for example, can "sink" their virtual vessels to test emergency evacuation routes. Virtual testing is gaining ground in the automotive industry as well. For example, IBM is currently working with researchers at the University of Iowa in the United States who have developed a simulator that allows engineers to virtually "test drive" a vehicle that is still in the design phase. By simulating how the automobile performs under various conditions, the product team can identify and address potential safety issues *before* manufacturing begins.



When design activities are performed digitally, they can often occur in parallel, shaving months off development cycles. Perhaps most important, a virtual product allows many tasks to be performed earlier in the development cycle — while a product is still in the design stage — when changes cost a fraction of what they would in production.



Principles of innovation

In manufacturing, the product that reaches the marketplace is the culmination of all the tools, methods and processes used by every person on the product-development team — whether inside or outside the company. Many of the following principles (though perhaps stated differently in every enterprise) have traditionally served as target objectives. What's new and noteworthy is *how* prominent manufacturers are putting these tenets into practice. By harnessing the unprecedented capabilities made possible by the Internet and digitization, industry leaders are "reinventing" the wheel of innovation and integrating their enterprise through a virtual product hub.

Delayed design freeze

While attempting to shrink the overall development cycle, many manufacturers have learned the importance of when and how they "freeze" a product's design. By delaying this critical milestone as long as possible, companies can remain flexible and responsive. They can incorporate new consumer insights along the way, optimize their designs and thereby improve the odds that the final product will actually appeal to the market when it's finally delivered.

In order to postpone the final design completion date, product makers must be able to perform tasks in parallel. Teams must also learn to work with incomplete information. For example, with a digital product design, engineers can insert a virtual placeholder for an incomplete component design. These "space corridors", which supply as much information as possible to the designers of surrounding parts, are replaced — component by component — as the design matures. This type of electronic collaboration, made possible via a single virtual product definition, can help geographically dispersed teams stay more informed and better coordinate design issues. For instance, an engineer might annotate the part she's designing to show a high confidence level in the overall size, but indicate that the position might change. Another engineer on another continent who is working on an interconnecting part could then suggest a position that works best with his current design. Instead of waiting for complete information or, worse, being forced to rework designs, the engineers can work faster and with more precision. Working virtually, teams can test individual components early; once the design is completed, only vehicle-level testing remains.

For this practice to succeed, the "design freeze" milestone must imply that the design is truly frozen — not just slightly chilled. Every function — from marketing to engineering to manufacturing — must be confident that the product they have *virtually* designed and tested is now ready to be produced in *physical* form.

De-coupled development

As any experienced project manager will tell you, parallel activity can accelerate schedules. Manufacturers are putting this axiom into practice on a broad scale by managing the development of individual components separately from the development of the product as a whole.

With this approach, the product is built primarily from existing technology; components currently under development are used only when there is a high probability of on-time completion. Technology-driven enhancements can flourish as independent programs, then — as soon as they're ready — work their way into the next iteration of the product. Since component development is no longer imbedded within a particular product's development program, engineers are free to choose between externally or internally developed components. Product *development* programs in effect become product *integration* programs. Leaders in this practice area are expert systems integrators; a few have successfully de-coupled the development of even their most expensive and critical components.

By integrating pre-developed components, manufacturers can respond faster to market opportunities. Increasing the percentage of carry-over parts — component designs that can be reused in another product — not only reduces cycle time but lowers risk as well. The component design is already complete and validated. Engineering and manufacturing knowledge — captured and managed electronically — is carried forward into the next product that uses the component. Some product makers have parlayed this practice into a full-scale program-development platform that manages each product as a generation within a product family. Guided by an overarching platform, a planned portion of the design is modified with each new model, and the manufacturer ends up with a totally reengineered product every fourth or fifth generation. Skilled integrators also incorporate customer feedback — not just as a one-time exercise, but as an ongoing, parallel activity.

For de-coupled development to work effectively, leading manufacturers must rely on a different type of supplier — one that provides a functional subsystem, rather than simply parts. For most manufacturers, managing integration at a subsystem level is more feasible than assembling smaller components themselves.

Partners not suppliers

Automotive manufacturers are striving to obtain up to 80 percent — sometimes 90 percent — of their product design from subsystem suppliers. Other industries are following suit. It therefore seems reasonable to assume that a commensurate level of innovation should be coming from those same sources. However, to achieve such gains requires the forging of a different type of supplier relationship — one that more closely resembles a true partnership. The days of playing one supplier against another to reduce cost — usually at the expense of the supplier's profit margin — are disappearing.

Innovative companies looking to exploit e-business are interested in more than simply finding the lowest price point; they also want access to the best ideas and solutions. These businesses prefer long-term, flexible agreements with a few trusted suppliers — and environments where less time is spent on administration and more on producing a better product. "Partners" can afford to provide systems at a lower price because they can amortize R&D costs across multiple product generations.

Within collaborative electronic environments, "guest" engineers from supplier organizations are brought in-house virtually to participate in an ongoing, realtime exchange of information and expertise. In this type of "partnership" situation — where proprietary design concepts and even financial data are shared openly — trust is crucial.

Parallel product and production design

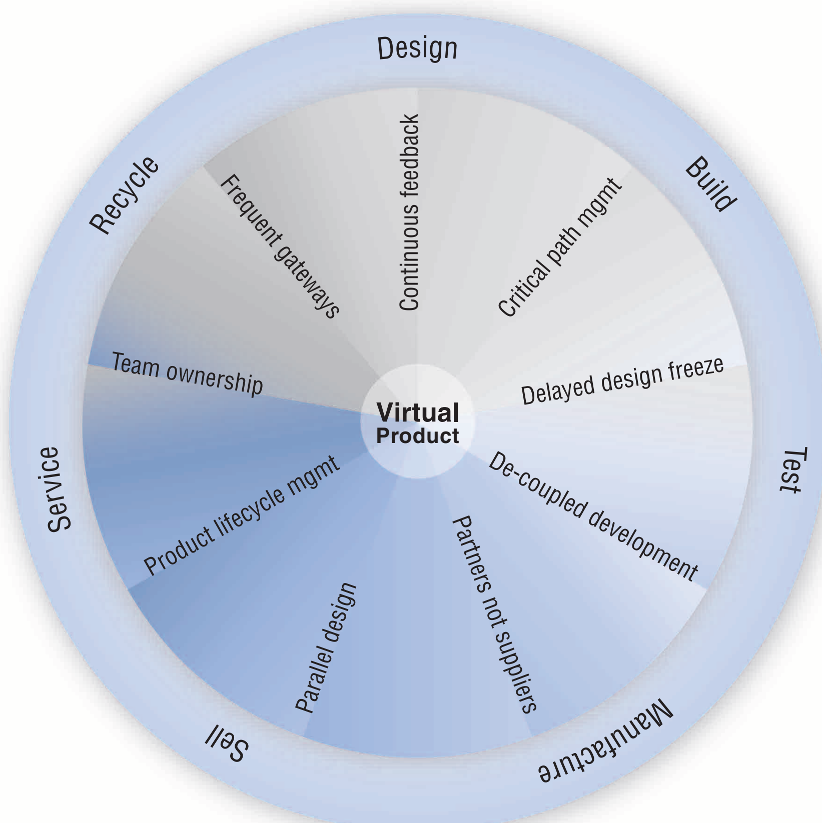
In the past, product makers worked relentlessly to improve manufacturing efficiencies because 80 percent of the cost was incurred during that process. Companies have now realized that by the time a product reaches the manufacturing stage, 80 percent of the production costs have already been "designed in". To positively impact production costs, speed and quality, businesses must concentrate on improving manufacturing *within the design process.*

The manufacturing teams of industry leaders no longer *inherit* a product design, *they influence* it from the very beginning. Not only is the production process represented by a member of the core product team, in most cases the majority of the other team members have production experience, too. Manufacturing considerations are factored into every design decision — from concept to design freeze. Through electronic collaboration, product teams can learn about local requirements that might impact the manufacturing process and exchange insights that can improve the product design. With advanced capabilities, such as formability analysis software and flow simulators, engineers can design better manufacturing tools and create them digitally. Engineers can then use these "soft" tools to "manufacture" digital product prototypes. By designing and testing the entire production process digitally — in parallel with the product — manufacturers can drastically reduce the time required for production ramp-up. They can also increase the likelihood of being able to actually manufacture the product as designed. The product design freeze can, in effect, become the manufacturing design freeze.

Frequent gateways

Gateways are predetermined points in the project development cycle where simultaneous activities are synchronized and decisions about project continuation are made. Project complexity — driven by de-coupled development and concurrent engineering — increases the risk of some tasks moving too far ahead and others lagging behind. With so many parallel paths, divergence, if left unchecked, can result in substantial rework and wasted resources. Gateways are control mechanisms that force convergence. With experience, manufacturers can learn to increase the number of gateways and decrease the duration of each — maximizing progress and minimizing cost.

With a virtual product, there's no need to wait for a formal gateway before assessing progress; the entire team, including the project manager, can literally *see* the current status at any time. Today's electronic groupware and workflow tools help formalize communications, keep



everyone abreast of the latest design and accelerate progress. Rather than bogging down gateways with lengthy project reviews or bureaucratic hurdles, innovative leaders tend to concentrate instead on binary “go versus no go” decisions that help the team quickly determine whether or not to move into the next phase of development.

Critical path management

Many manufacturing projects involve activities that entail unusually long lead times or extraordinarily high expense. In the aerospace industry, for instance, manufacturers use sophisticated materials that take substantial periods of time to create and require complex forming processes. In the automotive industry, design and construction of specific production tools — tooling that helps manufacture a car’s instrument panel, for example — can be extremely involved, not to mention expensive.

Complicated by a delayed product design freeze and a strong interdependence on product prototype activities, tasks with long lead times frequently fall along the product development critical path. Unanticipated delays in these activities can suspend the entire product development project; last-minute changes can quickly compound costs.

Industry leaders have adopted several techniques to help reduce the risk of delays and undue expense:

- *Structured project* plans with explicit milestones and gateways to keep production design and manufacturing aligned with product design and manufacture
- *Standardization* of, for example, tool design, number of operations, machining allowances, and pattern and casting processes
- *Digital prototyping* of tools and products. By using digital tooling to produce digital product prototypes during design, manufacturers can have the confidence to postpone creation of physical prototypes until production tools are in place. Because they have been designed in concert with one another, the product and the process to manufacture it are less likely to change. By postponing the creation of production tooling until later in the development cycle, some automotive industry leaders have saved many millions of dollars on a single vehicle program.

Team ownership

Innovators take teamwork seriously. In these companies, a small team of carefully selected individuals leads a product through development. Collectively, they represent each business discipline involved in getting the product to market — from marketing to engineering to service. Well-rounded experience is often more valuable than deep specialization on these teams, since bias in one area can sometimes lead to a sub-optimized product or process design.

Ultimate decision-making authority and issue resolution lies with the team. With empowerment, though, comes responsibility. The business holds the team accountable for meeting target dates — *and* target sales results.

Teamwork — especially among a geographically dispersed group — depends on effective collaboration and communication. The quality of a team's decisions depends in large part on the quality of information available to them. Electronic engineering environments can facilitate realtime knowledge exchange among the core team, as well as with other stakeholders both inside and outside the enterprise.

Product lifecycle management

In the quest for accelerated development schedules, it's tempting to think short term. Industry leaders, however, consider the full lifecycle of their products — from servicing to recycling — during the design process.

Savvy customers often weigh service costs as part of their purchase decision; product innovators concentrate on reducing the total cost of ownership. For example, the cost of maintaining a modern jet engine can exceed its initial purchase price — by as much as three times. Because of their long life expectancies, highly engineered products like airplanes must be designed to allow for continuous overhaul and repair. With a virtual product, manufacturers can electronically simulate routine service activities, like replacing a worn part. Early detection of maintenance challenges allows product makers to adapt the product design while it is still fluid. In some industries, serviceability requirements can play a dominant role in determining design. Imagine having to design a jet-fighter so that the entire engine can be replaced in less than thirty minutes by a repair crew in the field using "basic tools".

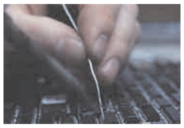
By incorporating on-board prognostic and diagnostic capabilities into product designs wherever possible, manufacturers can enable remote repair and substantially reduce maintenance costs. When actual "in-service" data is collected — from field service organizations or from the product itself — designers can gain a realistic perspective on product performance by comparing the data to original expectations. Areas of significant variance become candidates for future innovation.

Designing around the full product lifecycle also encourages engineers to make prudent decisions about component design and materials used — choices that can offer tremendous payback when it's time to recycle or pursue "after markets".

Continuous customer feedback

Continuous innovation depends on continuous interaction with customers; industry leaders not only gather requirements early, but also develop systematic ways of incorporating feedback throughout the product development cycle. By monitoring the pulse of the market, manufacturers increase the likelihood of market acceptance at product launch and help reduce the chance of costly "over-engineering". Local requirements are also an important consideration for global manufacturers seeking to serve different geographies. Innovators are typically business-intelligence experts; they know the value of routinely gathering consumer input from a variety of channels, analyzing and mining the resulting data to gain new insights, and incorporating findings into multigenerational product plans.

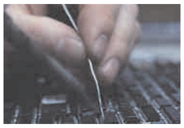
Still, understanding requirements is one matter; satisfying them is another. Through the use of virtual product technologies, manufacturers are finding new ways to confirm that consumer requirements are, in fact, being met. Rather than wait until an expensive prototype has been built, automotive manufacturers can invite customers to "virtual car clinics" where would-be buyers can browse through electronic showrooms to view virtual vehicles and provide feedback.



Inhibitors

Although our analysis shows that some companies have made strides in specific areas, few are world-class in every aspect. A few typical inhibitors are gating progress:

- **Integration** – Application complexity is higher than ever; yet efficient execution depends on a high degree of integration among systems. Manufacturers must connect product lifecycle management, customer relationship management, supply chain management and enterprise resource planning applications in order to build innovative products … profitably.
- **Infrastructure** – With rapid advances in information technology, an electronic engineering environment requires change almost as frequently as the products being designed; few product makers can keep up. Since managing a sophisticated IT infrastructure is seldom a core competency, manufacturers should consider entrusting their IT infrastructure to an experienced provider, just as they rely on strategic suppliers for important product components.
- **Intrusion** – Network connectivity — especially over the Internet — introduces an element of risk. Before they can encourage electronic collaboration among teams located both inside and outside firewalls, manufacturers must establish environments where data is adequately protected, without hiding information from those who need it.
- **Investment** – Cost is always a consideration; manufacturing based on a virtual product requires a substantial investment in terms of technology, as well as organizational change. Product makers should carefully weigh the potential payoff against the anticipated cost. However, when making strategic decisions concerning innovation, manufacturers should not dismiss the consequence of doing nothing.



Innovation in motion

It's important to remember that "best practices" are a moving target. Danger lies in complacency. In terms of innovation, a company standing still is most likely a company falling behind. If you're not absolutely certain which direction your manufacturing business is headed in, you might consider the following:

- How exactly are you *exploiting information technology* to drive accelerated product development and innovation?
- Do you deliver new and innovative products to your market through a *structured product development process* that is thoroughly defined, well understood and widely used across the enterprise?
- *Where* are you using a virtual product and electronic collaboration to reduce costs and drive additional revenues in your business today?
- Have you expanded the reach of your virtual product *beyond design* – into testing, production and post-sale support?
- Are virtual product techniques used *only by the "techies"* or by everyone involved with the product?
- Are various sites and departments — as well as partners and key suppliers — *linked together* in an integrated engineering environment so that they can benefit from synchronous data-sharing and collaboration capabilities?
- Has your board assigned responsibility for the business transformation required for pervasive virtual product use? Does the responsibility lie with an executive who has enough clout to *truly effect change?*
- Are you actively moving towards ubiquitous use of a virtual product? Do you have a *clear and achievable roadmap* to help you get there?

As a manufacturer in a fast-paced, dynamic industry, IBM understands the challenges that product makers encounter when attempting to accelerate innovation. Our industry consultants would welcome the opportunity to share insights from our work across the industrial sector and help you refine your innovation strategy and product development processes. If you would like to discuss how we might put our creativity to work for you, please contact us at *insights@us.ibm.com.* To browse through other resources for business executives, we invite you to visit:

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Produced in the United States of America
08-01

G510-1635-00