NEW DEVELOPMENTS IN NEW-PRODUCT DEVELOPMENT

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INTRODUCTION

Most people's notion of factory work is still modeled on Henry Ford's assembly line - a set of simple processes for turning out complex products. But that concept is as dated as the vision of Ford himself, in a green eyeshade and sleeve garters, toiling at a drafting board to design his Model T. Product development and manufacturing today is a complex new world, as intricate as the insides of a smart phone.

Consider that phone for a minute. It's a telephone, a camera, a computer, a music player, a calendar, a video game player, a Web browser, and a GPS, and it runs applications that do anything from simulating your puppy's bark to remotely programming your home air conditioning system. Designing and producing all that to fit smoothly into the palm of your hand is also at the edge of the envelope. But it's not unique; all products today are on the same arc of complexity. Twenty years ago, the biggest problem facing an engineer designing a Superman action figure was making the plastic mold look realistic. Now it has to walk and talk, with a repertoire of snappy remarks. The complexity level has jumped at least tenfold.

Manufacturing and product development has become almost a new profession, with its own lore, jargon, and acronyms

from CAD, CAM and EDA to ERP and PLM. And while business leaders and managers can't master every last wrinkle of what happens in their research labs and production facilities, they must understand the principles and most of the complexities just to stay in the race.

Chapter 1
TO DESIGN A PHONE . . .

My own company, PTC, may well be the biggest business you've never heard of. We've made the *Fortune* 500 list and the Standard & Poor 500 Index, pushing $1 billion in revenues, by providing software for product lifecycle management (that's the PLM acronym) for some 50,000 large and small companies around the world. In essence, we help them manage their product development and manufacturing processes.

I had my own small epiphany about the complexity of designing and building anything today when I signed up not long ago to build my own airplane from a kit. I ordered it up, expecting a neat collection of parts and a set of directions, and one day a semi-trailer showed up and unloaded a jumble of several thousand parts - at least twice what I was expecting, or needed for that matter. It was bewildering, and the directions were more like clues in a scavenger hut. When I called to complain, the company just referred me to the online community of my fellow-builders - people around the world who are building the same plane and sharing their problems and solutions as they go. It's a vibrant community, with hundreds of postings a day, and it's full of information on how to build the plane, how to

customize it, and such issues as whether you have to use certified aircraft engines or can just buy a used auto motor.

Imagine designing a product - not my plane - much too complicated to begin to describe, but something relatively simple, an ordinary telephone.

You'll be using computer-aided design (CAD), both mechanical (MCAD) and electronic (ECAD), which are both parts of electronic design automation (EDA). There's two-dimensional CAD for drawings and three-dimensional for models. A phone nowadays has not only mechanical and electronic parts, but also software to manage message storing and retrieval, and you need to figure out, for instance, how much wire you'll need and how to route it, which memory chip will work and who supplies it at what price, whether to build your own circuit board or buy it, and so on for each of literally hundreds of parts that make up the phone. You need to know the cost and source of each part before you can decide to build your phone.

That gets you into product data management (PDM), since you have to keep track of hundreds of facts about each design variation you're considering. When I look at a phone, I see perhaps 200 files of data in MCAD alone. Each of the 12 basic buttons (1 through 0, plus # and *) has its own file, covering all the parts it contains and all its links to other parts, and you'll build files for the redial function, the speakerphone, the ringer, the headphone jack, and so on. If you have options that might require a more powerful chip, you may have to design a different connection for it, which might affect other parts down the line. You are literally swimming in data, so you need databases to collect it and tools to help you find and look at whatever you

need to see at any given time.

All through the design phase, you have great flexibility at very little cost. You don't want to go with your first idea on any option; you want to keep experimenting, changing designs and parts, and keep testing the overall design with consumers and suppliers, until you wind up with the best possible product. An idea you don't use becomes an intellectual property asset that could well be useful on some other project. It's when you get from the digital world of design to the physical world of production that change becomes a problem. When you have to change a design on the manufacturing line, it can be a disaster - another reason to make sure you get it right in the first place.

Chapter 2
. . . AND THEN TO MAKE IT

After you have designed your phone, you have to plan the process of manufacturing it, putting all the pieces together in logical order, with assemblies and subassemblies. You'll use computer-aided manufacturing (CAM), with databases that track and control what's happening in real time on the shop floor. At the extreme, some people want to design the entire factory and be able to watch on computer screens as robots pick up the phones, add or alter a component, and put them down again.

The complexity of the design and production process becomes monumental when you get into a product like a jetliner, with design and production variations for each airline customer and even within a single plane. The documentation for each plane would outweigh the aircraft itself if you had to print it all. So you have to create a unique set of databases for each plane. It's as if your car came with an owner's manual that covered only the options the car is actually equipped with, instead of instructions for all the available accessories. Then you have to create a service program, telling the customer how to maintain the jetliner, and a database to keep track of what is actually

done to it, a permanent record of every service from oil changes to major repairs - for instance, whether its General Electric engines were replaced with Rolls Royce engines along the way.

All the design and production data become part of your enterprise resource planning (ERP), the software used to manage all your internal and external resources - your finances, your employees, your suppliers, and your customers. ERP sees your business as an integrated organization and keeps information flowing freely through the whole system.

And while databases actually control and manage much of the design and manufacturing process, the important decisions are made by collaboration among managers deciding on the rules that go into the databases. There's always tension, for instance, between the designers, who tend to want to make the most sophisticated, high-end products, and project managers, who want to keep costs down. Managers use all the available data to analyze and optimize the product along all its dimensions - cost, reliability, on-time delivery, and many others. To name just one factor in such an analysis, there's strategic risk with suppliers. When Mattel's managers decided to outsource manufacturing to China, it turned out they had bought into a huge strategic risk of lead paint on their toys.

Finally, managers have to oversee the entire manufacturing process, up and down the supply chain. In producing that ordinary telephone, for instance, it wouldn't be unusual to have 30 or 40 suppliers that are supposed to work together but possibly don't function all that well.

When you look at the overall product design and manufacturing processes, what you see is a degree of complexity

that technology alone can't handle, which is where human experience and judgment take over. The need is to stitch all those moving parts together to form an integrated product development system - a genuine system, uniquely tailored to each company's goals and culture, so that everyone involved with a product can understand everything about it.

Inevitably, although we're focusing on design and manufacturing, the product development system has to take account of factors ranging from pricing policy and supplier relations to the corporate culture itself. Since value is created when everyone in a company is focused on turning out great products, we have developed a value roadmap that will make that goal a reality.

In practice, how can you cope with the ever-rising level of complexity in your design and production processes? Here are five suggestions for general approaches.

- Wherever you can, simplify.

  In recent years, the retail clothing business has become a paradigm of complexity. In search of economy and efficiency, companies routinely outsource the production of their products, with supply chains stretching around the globe. As *The Harvard Business Review* has noted, the filling for a down jacket might come from China, the outer shell fabric from Korea, the zippers from Japan, the inner lining from Thailand or Taiwan, and the elastics, label, and other trim from Hong Kong. The fabric might be dyed in India or Bangladesh and stitched together in China, with the

finished product inspected for quality and packaged in Hong Kong, and finally shipped to a store in Europe or North America.

This cumbersome business model may be efficient for some, but counterproductive for others. Zara, the Spanish-based "affordable chic" chain now rivaling The Gap for the title of the world's biggest clothing retailer, has thrived by streamlining its supply chain. It makes the key elements of its goods in its own factories in Europe, offsetting the higher production cost with lower transportation bills and the ability to respond more quickly to market trends. While its rivals might need three months to restock a garment and six months to design and manufacture a new one, Zara can restock or modify an item in two weeks and move a whole new design from concept to store shelf in just four to five weeks. Thus the chain can wait longer than its competition to commit to a season's product line, order smaller batches, and restock quickly when it sees what's selling.

In other businesses, cutting costs can be neatly combined with achieving a greener image. By developing new packaging materials, for instance, Britain's Tetley Tea managed to load twice as many of its products onto a pallet, and thus cut the number of truckloads between factory and warehouse by 28 percent. And when delivering goods to its customers, Tetley arranged to fill at least part of the returning empty trucks with goods to be delivered for the customers, achieving both fuel efficiency

and new revenues.

Following a company's value roadmap may also produce economies only distantly connected to design and production. The British retail chain Marks & Spencer has been recognized as a sustainability leader by committing to "Plan A," a program to cut energy costs in all its operations by 25 percent by 2012. Among a host of small improvements, the chain will replace 90-watt light bulbs with 75-watt bulbs in all its stores, cutting lighting costs by 17 percent - with less heat from the bulbs producing a side benefit: reduced energy needs for refrigeration and air conditioning. Similarly, companies are learning to use "dynamic pricing" to persuade their customers to buy whatever goods are most available. When Dell Computer had a shortage of components from Taiwan after an earthquake in 1999, the company adjusted its online prices to induce customers to buy computers with parts made elsewhere.

- Think through every process.

  Successful design is driven by innovation, and the world of innovation is driven by brainstorming ideas and then thinking them through, checking and rechecking every possible variation and how each possibility might change the process up and down the line. All this takes scrupulous, systematic thinking, and it wouldn't be possible in practice without the databases that force you to follow every variable.

  But the results are well worth the effort. One of our

clients, the Volvo Group, offers more than 250 modular building blocks for making trucks to its customers' specifications. The modules include power trains, brake assemblies, cooling systems, fuel tank components, and the like, and the individual units often have to be modified to work together. Volvo's digital mockup teams evaluate each overall configuration, testing the compatibility of all the parts. When such design problems are spotted early, they can be fixed far more easily and cheaply than when the modules are actually being assembled.

- Anticipate and deal with the inevitable tensions in your integrated system.

  The clash between designers seeking the best and managers monitoring costs is symbolic of the chronic tensions between those who need to make profits and creative people for whom the work is the main reward. That contest is forever, and the only way to deal with it is to recognize it and make both sides accept the need for compromises. If designers include cost in their criteria for excellence, they can sometimes do wonders; just consider computer chips and the doctrine that their speed doubles even as prices drop by half.

  But there are other, perhaps more troublesome tensions as well. Creative people and marketers alike tend to be informal and fast-moving; they hate to be slowed down by bureaucratic rules, too much paperwork, and mandated processes. On the other hand, the

organization needs information in a form that can be used. At PTC, we used to send in expense reports on a simple Excel form. It took literally 10 minutes to type in the data, print the form, staple the receipts to it and send it in, and everyone who used the system was perfectly satisfied. But the company needed to know a lot more - how much we were spending annually on which airlines, how much tax we owed to which European governments, and so on, without shuffling through all those receipts. So we got a much more elaborate, governance-based program that could sort out all that data at the click of a mouse, and the task of filling out an expense report jumped from 10 minutes to an hour. For the executives, it was a hassle, but it met the needs of the organization.

Similarly, salespeople don't want to waste time figuring out and sending in their individual sales estimates - but companies need that information to make their market forecasts. Designers would love to use individual desktop tools for their projects, but they have to employ a centralized design platform so that everything works together and all the data can be shared. In the end, we live with the tension, and the needs of the company govern.

- Turn complexity to your own advantage.

  Zara may have simplified its supply chain, but its business is based on a unique and complex value roadmap. The largest of eight retail chains owned by

Inditex (Industria de Diseño Textil), Zara appeals to its customers by reacting quickly to fashion trends. It aims not to originate fashion, but to take advantage of what's happening in its market by, for instance, whipping out copies of the outfit a rock star wore at a recent concert.

Like its competitors, Zara outsources production of such standard items as T-shirts to factories in Asia and North Africa. But most of its fashion-sensitive garments are made to order in its European workshops or by independent but closely monitored nearby suppliers. Its worldwide stores are stocked from two distribution centers in Spain, where a just-in-time system ensures that inventory never lingers for more than three days. Three-fourths of the merchandise moves by truck, reaching European stores within 24-36 hours; air freight to Asia and the Americas arrives within 48 hours.

Zara's 1,608 stores are spread through 74 countries, mostly in upscale shopping districts. Store managers keep daily logs of what's selling and confer with headquarters not only on what their customers buy but what they want and can't find - which the chain's 300 designers are quick to provide. The managers are given wide latitude in their orders, and get deliveries twice weekly. But the orders come in small batches, to minimize the risk of overstocking and to take advantage of Zara's quick response to reorders. About three-quarters of each store's inventory is replaced every three to four weeks.

As a member of the Inditex board put it, the formula "is all about creating a climate of scarcity and opportunity. We want our clients to enter a beautiful store, where they are offered the latest fashions. But most important, we want our customers to understand that if they like something, they must buy it now, because it won't be in the shops the following week." And the customers get it. The average Zara shopper visits one of its stores 17 times a year. Shoppers at rival chains come in every three to four months.

- To serve your clients, grow even more complex.
  General Electric pioneered the practice of bundling services with the products it sold, offering its customers not only turbines, locomotives, or medical equipment but solutions to business problems. In effect, GE uses its products as a point of entry to function as its customer's trusted business consultant, learning more and more about customers' operations and broadening the services it offers.
  Companies using this strategy must be sensitive and willing to work hard at learning the nuances of their customers' business. But as IBM has done with its consulting, and as Best Buy's Geek Squad has proved on the retail level, adding to complexity by bundling products and services can increase revenues and profit and add to customer satisfaction well past the point of sale. In Hong Kong, the giant trading company Li & Fung uses its network of more than 6,000 suppliers across

Asia to provide customers with services ranging from design, sourcing, and supply management to logistics and quality inspection.

- Think about open-sourcing product development.
  For most managers, this is a slightly disturbing notion. While they are used to the idea of viral marketing and even using Facebook, LinkedIn, and Twitter to reach out to their customers, they see product development as proprietary and shy away from exposing their intellectual property to any outsiders.
  My view is diametrically opposed: I see social networking as the inevitable next step. Product development has essentially gone through two historical stages. All through the industrial revolution, a product began with an individual genius - Eli Whitney, say, or Thomas Edison - who had an idea and brought it to market. Gradually, as the process became more complex, the individual gave way to the organization, and the people who actually did the work became company assets who collaborated in product development.
  Now we have technology that makes it possible for this collaboration to be done by a whole community, operating on open networks. Most companies using such networks still keep product development within the corporate walls. In a giant company like Motorola, for instance, two engineers who have never met can find each other and share expertise on choosing materials for a new product, all without any official approval

or even the awareness of project managers. It happens spontaneously, on the edge of the enterprise, as opposed to a central database that must be elaborately updated and controlled. But the intellectual property is still protected by the firewall as Motorola assets.

Such networks are tremendously appealing. Yammer, for instance, is a social technology for networking within a firewall. It's modeled on Twitter, texting messages in a maximum of 140 characters, and it's used as a way to keep all the product managers in touch with each other. In one company I know that recently installed Yammer, it started slowly, with perhaps 75 users. But within eight weeks, the network had grown to 1,500 to 2,000 members. The pull has been tremendous.

But my plane-building experience provides another insight: It's time for most businesses to tear down the firewall and move product development to a new third stage, making it open to anyone who wants to volunteer knowledge or expertise. A few leading companies are actually going online to help solve their problems; Procter & Gamble, for instance, launched its "Connect + Develop" program in 2002 to reach out for new product ideas and cut the time and cost of developing them. When P&G wanted to print text and images on its Pringles potato chips, the process it found in the Web community had been developed by an Italian professor, who partnered with P&G in adapting it for Pringles. The company sees its experiment in social product development as a huge success, a major factor in its

double-digit growth in sales and profits since 2003.

Inevitably, more and more companies will do the same. Social networking is simply the way people think these days. Young people coming out of school will feel stifled if they can't use all their collaborative, multitasking abilities to text, send instant messages, and use wikis and social networks. You can say they aren't allowed to go outside the firewall, and they'll either do it anyway or go to work for someone else. The chief information officer of one of our customers told me recently that he knew that his engineers were sharing proprietary data with their suppliers, and he was dying for a way to get that under control. He'd do better to accept the practice, and figure out a way to develop some competitive advantage around it.

That's the rationale for a fascinating new venture that threatens to revolutionize the whole auto industry. In Wareham, Massachusetts, Jay Rogers and his startup, Local Motors, have recruited designers from all over the world to develop designs for new cars, and they are selling the cars to people who will come to Local Motors microfactories - local garages, in effect - and personally help to build them, under the guidance of professional mechanics.

Local Motors has come up with its first design, an off-road muscle car called the Rally Fighter, and is working to pull together another set of plans for a pickup truck. The cars are designed to be built from standard components made by conventional auto companies, with

variations to suit the buyer's taste (one early purchaser is building his Rally Fighter with a diesel engine). Rogers says the parts cost $24,000 or less per car, depending on the owner's preferences, and the assembly work adds up to $6,000, depending on how much labor the owner actually contributes. Rogers hopes to build 25 microfactories in the next 5 to 10 years at a cost of $5 million each, with each of them turning out 2,000 cars per year.

If the whole idea sounds oddball to the point of absurdity, consider that General Motors and Chrysler are struggling out of bankruptcy in pursuit of the conventional approach to making cars. Local Motors has found venture capital totaling $4 million and is looking for another round of $10 million or more. Forbes magazine included it as the most "non-traditional" in a roundup of six automaking startups in the wake of the industry's troubles, and the *Harvard Business Review* took Local Motors seriously enough to feature it in March 2010, in a 20-page report, "Designed by the Crowd, Built by the Customer."

Believe it. Social product development is the third major step in manufacturing, and the wave of the future.

ABOUT THE AUTHOR

James E. Heppelmann is president and chief executive officer of PTC, a leading maker of software that helps 50,000 corporate clients manage their new product development and manufacturing processes. He has worked in the information technology industry since 1985, developing and deploying large-scale information systems. Here he describes ways of coping with the increasingly complex problems of developing and producing today's goods, with some practical suggestions for those who must do it.

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