TUCK SCHOOL OF BUSINESS AT DARTMOUTH
WILLIAM F. ACHTMEYER
CENTER FOR
GLOBAL LEADERSHIP

The John Deere 8030 Tractor

Just after sunrise on a brisk February day in 2006, in the rolling hills south of Waterloo, Iowa, Bob Recker, a 40-year veteran of Deere & Company, helped me aboard a technological marvel: a modern, 8000 series John Deere tractor. Until that moment, I suppose "tractor" meant not much more to me than "big lawn mower." I grew up in suburbia. I had a lot to learn.

The tractor I climbed aboard was not just big, it was *very* big. The rear tire alone stood 7 feet high. The tractor weighed 12 tons, five times more than an average sport-utility vehicle (SUV). It was also comfortable. My mental picture of a tractor included a driver sitting in open air on a metal seat. I discovered this picture was out of date. This tractor had an enormous enclosed cab and a cushioned seat, with an independent electrohydraulic suspension that eliminated 90 percent of the vehicle's vertical motion as it passed over bumps, ruts, and rocks.

Once situated in the cab, Mr. Recker fired up the engine and off we went. I suppose some measure of disappointment was inevitable. Tractors are slow, and we were on wide-open, featureless terrain. This ride would not qualify for an e-ticket at Disneyland. The tractor's top speed—26 miles per hour—I could easily exceed on a bicycle.

Still, when Mr. Recker began to describe some of the features inside the cab, my interest level picked up again. It quickly became evident that I knew as little about the business of farming as I knew about tractors, and you couldn't understand one without understanding the other. For example, the tractor is the workhorse of the farming operation, a vehicle designed to tow a variety of farm implements, including tillers, planters, sprayers, cutters, scrapers, and harvesters. Further, to earn a profit, farmers needed to make every process in the operation as efficient as possible.

Farm economics, strangely, explained the high-tech seat. Initially, I was perplexed about why farmers would need such an expensive creature comfort. Perhaps that attitude allowed Deere, and even Deere's customers, to overlook the importance of comfort for many years. In harvesting season, farmers rode tractors from dawn to dusk before retiring to office work, and every minute counted. The fewer rest breaks the operator needed, the better. Plus, operator fatigue led to errors, and errors translated directly to the farmer's

---

This case was written by Professor Chris Trimble of the Tuck School of Business at Dartmouth. The case was based on research sponsored by the William F. Achtmeyer Center for Global Leadership. It was written for class discussion and not to illustrate effective or ineffective management practices.

profit or loss. In addition, large-farm owners who hired drivers wanted them to be so comfortable that they were happy thinking of the tractor as their second home.

Mr. Recker soon introduced me to the tractor's electronics. These included wireless data links to fixed computing systems that calculated crop yields at specific points in the field, and a navigation system connected to Global Positioning System (GPS) satellites. Farmers needed the navigation system not to find their bearings but for precise driving. Deere's AutoTrac feature, for example, calculated the shortest path for driving over every inch of a field of any shape and size. AutoTrac also made steering semiautomatic, ensuring that each pass across the field was precisely aligned. Average drivers, in an effort not to leave gaps, overlapped about 8–10 percent of the previous row. That meant 8–10 percent wasted time, gasoline, fertilizer, pesticide, seeds, etc.—a painful bite into the farmer's profit margin. With AutoTrac, the overlap was 0.[1]

The need for precise operation of the tractor and its towed implements explained other features as well. For example, the value of one breakthrough design element in the 8000 series, the drop-box transmission, was that it enabled the engine to be positioned higher. That, in turn, gave more clearance for the wheels and allowed a tighter turning radius. Recent innovations in hood design improved driving by improving visibility, which inevitably suffered as engines became bigger and more powerful. The tractor even had electronic controls for precisely adjusting the height of a towed implement. One of the newest innovations was an infinitely variable transmission. No longer would operators have to choose, say, to be in 14th or 15th gear; they could dial up a gear at any fractional increment in between. That enabled precise and independent control of the tractor's speed, the engine's speed, and the implement's speed.[2]

Farming had truly gone high tech.

The 2005 Agritechnica Exhibitions

H.J. Markley took in an awesome view. It was November 2005, and Mr. Markley was in Hannover, Germany, attending Agritechnica, the world's leading agricultural machinery exhibition. Spread out before him across several acres were the latest, most innovative new products the industry had to offer. Fifteen hundred companies from around the world presented their combines, tractors, planters, harvesters, bailers, mowers, and more.

Earlier that day, an expert commission had awarded one of only four gold medals to the newest large tractor from Deere & Company, the 8030 series. Mr. Markley, on Deere's

[1] After seeing the AutoTrac, I couldn't help but ask, Why not unmanned tractors? In fact, the AutoTrac does free up enough attention that the driver can easily be on the phone, say, checking commodities prices rather than concentrating on accurate steering. But the liability issues associated with an unmanned 12-ton machine were likely to keep operators in the cab for years to come.

[2] There were certain operations where the right combination of speeds was crucial, including pulling beets and potatoes from the ground. To be most efficient, the operator had to cushion the vegetables with loose dirt but avoid pulling too much dirt out of the ground, which added unnecessary work.

senior executive team, was elated for the team of engineers that had worked so hard—six–seven days a week, 12–14 hours a day—to get the product to market on time. "For the design team, it was like winning a Nobel Prize," he reflected.

When the design process for the 8030 began in 2001, there was one design criterion not open to debate. The 8030 would have to meet the most stringent emissions standards to date: Tier 3 standards, due to go into effect on January 1, 2006. In 1994, the Environmental Protection Agency had enacted new laws drastically reducing allowable emissions from diesel engines. These Tier 1 standards went into effect in 1998 and were subsequently appended with even stricter Tier 2, Tier 3, and Tier 4 standards. Deere's sequence of new product launches from the late 1990s on was coupled with the sequence of new emissions standards. Tier 4 would go into effect starting in 2011 and would bring diesel emissions down to 0.25 percent of that of a 1994 tractor. "The exhaust from an 8040 series tractor[3] will be cleaner than the air on a bad day in congested city," claimed Mr. Recker.

These new emissions requirements presented a problem to tractor designers. The technology to reduce emissions—exhaust after-treatment systems—was available, but there was a trade-off to cleaner exhaust. Better particulate filters and catalytic converters would create back pressure on the engine and reduce fuel efficiency. This was no small consideration. People who farmed for a living could not be nearly so capricious about fuel efficiency as, say, a middle-class American driving an oversized SUV. Profits on a farm could never be taken for granted, so farmers watched fuel efficiency closely, especially in Europe, where prices at the pump were two to three times higher than those in the United States.

Mr. Markley, president of Deere's agricultural division (see Figure 1, Organization Chart) at the time, reflected on the mood of the 8030 product development team in the earliest stages:

> The market was demanding what nobody knew how to deliver. Even though all engineering reason and logic told us that meeting the more rigid Tier 3 requirements was inconsistent with the desire for better fuel efficiency, the engineers willingly took on the challenge. As it turns out, they did some of their best work in this apparent zone of impossibility.

There were two ways to improve fuel efficiency: either by improving the engine design or by reducing the energy demands of the "parasitics," the array of components other than

[3] The numbering system for Deere's tractors indicated application, engine size, and emissions-control level. The 8000 series tractors, first launched in 1994, were the most commonly used two-wheel-drive Deere tractors for large-farm row-crop (e.g., corn, wheat) applications. Deere launched a new product series every few years as the emissions requirements escalated. The 8010 series met Tier 1 standards, the 8020 met Tier 2 standards, and so forth. Within these groups, the tractors could be configured with engines of different sizes. In the 8030 series, the 8130 tractor had the smallest engine and the 8530 had the largest. In 2006, a well-equipped 8530 tractor came with a price tag in excess of $200,000.

the drivetrain that drew power from the engine (e.g., fans and hydraulics). At the beginning of the design process, nobody expected much improvement from the engine itself; it seemingly had been pushed to the limit in previous designs. As such, the team focused on the parasitics.

The team succeeded not only in making parasitics more efficient but also in improving the engine's performance—a pleasant surprise. At the time of the Agritechnica exhibition, the Deere team expected the 8030 would deliver at least 5 percent, and perhaps as much as 15 percent, improvement in fuel efficiency over the 8020. Independent testers would measure the precise figure during the summer of 2006.

The timing for the 8030 launch appeared good because fuel prices had doubled while the 8030 was being designed. Although farm economics were not particularly strong as the 8030 went to market, the Deere team was brimming with excitement.

Deere's Product Engineering Center Reaches 50

My demonstration ride took place just outside Deere's Product Engineering Center (PEC). Since inception in 1955, the PEC has been home for the company's tractor-design activities.[4]

For the four decades prior to the formation of the PEC, Deere had offered family farmers workmanlike and well-loved two-cylinder tractors, known affectionately as Johnny Poppers or Poppin' Johnnies.[5] But by the 1950s, the agriculture industry was evolving to favor larger, more efficient farms. Bigger farms needed bigger equipment and, in particular, more powerful tractors. Knowing that a two-cylinder engine design faced obsolescence, Deere & Company established the Product Engineering Center to reposition the company for the future.

In 2005, around the time the 8030 design was completed, the Product Engineering Center reached its 50th birthday. To mark the occasion, the company produced a brochure detailing the key innovations of the past 50 years. In the centerfold lay a timeline featuring major new product releases, such as the six-cylinder 4010 tractor, with an eight-speed transmission, introduced in 1960; the first turbocharged engines later in that decade; improvements in hydraulics in the 1970s; and the proliferation of electronics in more recent years.

[4] The original PEC was located in Cedar Falls. It was reestablished in Waterloo, the site of my demonstration ride, in 1977.

[5] Deere first offered tractors after purchasing the Waterloo Gasoline Engine Company in 1918. Before 1918, Deere was only in the farm implements business. According to one Deere executive, at the time of the acquisition, some company leaders worried that the move into tractors was unwise. It appeared to be a risky gamble on an unproven technology and a move outside of Deere's area of expertise, implements. Not only that, it was sure to anger the company's business partners in the horse industry who, understandably, viewed the internal combustion engine as a threat.

The timeline also revealed a decade of darkness. In the 1980s, the farm economy in the United States was deeply depressed. U.S. grain exports plummeted. Land prices in Iowa tumbled by two-thirds. Farmers struggled to stay in business, and major purchases of new capital equipment were out of the question. As a result, product development at Deere & Company nearly ground to a halt.

When Deere & Company emerged from the downturn and launched the design effort for the first 8000 series tractor, it was the cleanest sheet from which they had designed a tractor since the PEC's inception. Everything, except the engine, was brand new.

It was not clear that Deere's PEC was ready for the challenge. In past design efforts, experienced individuals understood and guided the process from end to end; they understood customer needs and the products. But the experience base atrophied through the 1980s, as did relationships with suppliers. In addition, the product development process was becoming more complex, with many thorny interrelationships between components.

Thanks to the rapid proliferation of cheap microprocessors during the 1980s, the 8000 series would also be more dependent on electronics than anything the company had ever designed before. Electronics were so prevalent, in fact, that by 2006, Mr. Recker viewed the tractor not as the mainstay of the farming operation but as a carrier of the technology platform. The design teams, traditionally dominated by mechanical engineers, needed to absorb engineers from unfamiliar disciplines, such as electrical engineering, software engineering, and computer science.

The complexity was daunting but the opportunities were rich. Against the desire to maximize these opportunities, the design team had to be mindful of the John Deere brand promise: extremely high reliability. Deere customers routinely reported that reliability was what they cared about most, followed closely by how quickly it can be fixed if it breaks. This orientation reflects economic realities on the farm. The window for harvesting a crop is narrow and weather dependent. With respect to their machinery, farmers fear nothing more than a breakdown at just the moment they need it most.

In normal times, this mandates conservatism in the product development process, but the 8000 design process did not commence in normal times. Mr. Recker recalled the energy surrounding an early skunk works meeting:

> This one individual, now retired, saw the possibilities, and he just got together with a mechanic and some creative engineers and started telling a story about how it should be possible to build a great tractor with a tight turning radius and perfect visibility. He had been inspired by watching operators struggle to maneuver tractors in tight spaces. The conventional wisdom, however, was that if you needed power, you needed a big engine and big wheels and a big hood, and there was no way to have that combination plus a tight turning radius and good visibility. But he inspired the group, and they started tinkering and moving

components around and, eventually, they came up with the solution of a raised engine with a drop-box transmission.

The legendary notion of a "few guys in a garage" working their magic and achieving big breakthroughs inspired some, but most managers at Deere felt that it was no formula for end-to-end product development. To manage accelerating complexity, the company began investing heavily in creating and refining a formal process, eventually dubbed the Product Delivery Process (PDP).[6] Through the subsequent decade, entire new managerial roles evolved that focused on nothing other than documenting, measuring, and improving it. The process ensured specific collaborations where needed, set demanding schedules, identified necessary resources, and so forth.

Several senior executives attributed the (pre-market) success of the 8030 to the process itself. The process had to be outstanding, in their view, because of the nature of the industry. One Deere executive described the supplier community as "insular." At the component level, all tractor manufacturers were working with the same technologies. Thus, in the view of Deere's management team, overall product design could be the only source of competitive advantage. If Deere tractors were to be best, it had to be because of the smooth *integration* of a diversity of advanced technologies. That, in turn, could only be accomplished with a well-constructed, clearly defined product development process.

The Development of the 8030

In early 2001, Scott Toppin took on leadership of the largest and most crucial product development effort at Deere, the 8030 tractor. He had spent 25 years in engineering at Deere, the most recent decade developing new products. Besides insisting on improved fuel economy, Mr. Markley cautioned Mr. Toppin that it would be wise to get robust input from the marketing department even earlier than they had in the past—in other words, right away.

In fact, the marketing lead for the 8020 series tractor, Brian Arntson, was immediately reassigned to support Mr. Toppin in the 8030 effort. His role was to represent the "voice of the customer" throughout the design process.

Deere's customer base had evolved into two very distinct segments. One segment was a group that either sentimentally held on to the notion of family farming even as its economics deteriorated or wanted a simple, economical way to generate a bit of extra income. Deere would market its smaller machines to this segment and would find it had to educate some of these customers on concepts like "total cost of ownership." The 8000 series tractors were intended for the other segment: large-farm owners who were in business for profit and who had a deep understanding of the economics of the business.

[6] The choice of product *delivery* process rather than product *development* process conveyed that the process extended post-launch to customer delivery and subsequent servicing.

The 8020 would be the starting point for the design of the 8030, and Mr. Arntson was already aware of many features that did not make the cut on the 8020 that he wanted to see reconsidered for the 8030. To get additional feedback, the company reviewed results from its Satisfaction First surveys, sent to each new owner of an 8020 tractor. Deere benefited from high customer loyalty and thus experienced a very high participation rate in surveys. According to Mr. Arntson,

> Our customers are extremely loyal. They wear John Deere coats, use John Deere mailboxes, and fly John Deere flags. Even in cities, if you say, "green and yellow tractor," people think John Deere.

The company also surveyed a select group of 8020 owners on the desirability of proposed new features for the 8030.

In addition to reviewing survey data, marketing executives flew around the world to talk directly with customers and get face-to-face impressions of their real needs. They also reached out to dealers for feedback, and they studied competitors by getting a group of farmers together and asking them to compare Deere directly with the competition, feature by feature.

Based on early input and extensive debate and discussion, Mr. Toppin and his colleagues formulated the top five design goals: more power, less noise in the cab, an infinitely variable transmission, a bigger hitch to pull even heavier implements, and, of course, the ability to meet Tier 3 emissions requirements. Reducing the list to these five goals required identifying the most pressing customer needs and the greatest opportunities to differentiate from the competition. The team was also mindful of three primary constraints: the price the customer was willing to pay, Deere's total capital expenditure, and a "packaging" constraint. "At the end of the day, it had to look like a tractor," commented one engineer on the team.

This outline of design principles constituted the conclusion of the design effort's Phase One, the first of five phases. Phase Two involved specifying the design in much greater detail. More than 50 engineers worked full-time for over one year to prepare component specifications, cost calculations, estimates of necessary capital spending, bills of materials (including part numbers), and a schedule for getting from preliminary design to routine manufacture. Even with this higher level of detail, the design work was still full of estimates and educated guesses—as much art as it was science.

During Phase Two, possible feature additions were considered more carefully. The team set aside a three-week period for new-technology assessments. During that time, they chose to add a variable-speed fan to help reduce cabin noise. The fan was part of the engine cooling system and in past models had run at a single high speed, sufficient to keep the engine cool on the hottest day imaginable. Most of the time, however, the engine did not need nearly so much cooling, so the team added automatic controls and a variable-speed drive to quiet the fan. A side benefit was additional fuel savings.

At the same time, the team declined to add many more possible innovations, even ones for which customers were asking. For example, they did not add a new front "power take-out," an extra auxiliary drive that would enable a second implement to be pushed in front of the tractor. That was a feature that several marketing managers were pushing for, as were several branch offices in Europe. They also declined to add a large enough electrical generator to drive additional auxiliary equipment running on independent electric motors.

The ever-present challenge in making such decisions was to balance risk and reward. Was the new technology really ready? While there was always excitement about new possibilities, reliability was always the customer's number-one concern.

In the summer of 2003, Mr. Markley and his colleagues on the senior management team authorized the plan and associated expenditures—Deere's largest tractor development budget in over a decade—and the project moved on. In Phase Three, all engineering was completed in full detail, and the team produced the first demo, a "durability build."

The group facing perhaps the most difficult set of constraints during the design process was the engine design team. Dean Anderson, lead engine designer, faced both ambitious goals and tricky constraints. He needed to produce an engine that was higher in power, higher in fuel efficiency, and much lower in emissions. Further, because engine manufacture was extraordinarily capital intensive, he was constrained by some manufacturing equipment that Deere had been using for over 30 years. Mr. Anderson knew that his peers at other companies faced the same issues. The community of designers of large diesel engines was small and tightly networked. They all read the same technical journals and attended the same conferences. Most had worked for more than one company that operated in the space, such as Caterpillar or Cummins.

From manufacturing equipment originally designed for a six-liter engine, with a fixed engine-block size, Mr. Anderson somehow needed to create a nine-liter engine. That required a design with thin walls, which, in turn, required using newer, stronger alloys. To increase power output, Mr. Anderson's team also doubled the number of valves per cylinder. All of the work was done first on computer, using such techniques as finite element analysis and computational fluid dynamics. The result was a very tight fit and thus a complex engine-block casting, pushing the limits on existing "thin-wall casting" technology.

Deere & Company took pride in designing engines that were well integrated with a specific machine, rather than mass-produced engines. This led to greater cost but also greater quality and reliability. Any change Mr. Anderson made in the engine design had implications for design of other parts of the tractor. Because of the complexities, engine design lagged behind the rest of the tractor design. Mr. Anderson described the resulting anxieties:

> It is never fun to fall behind schedule. As the design process proceeds, the cost and complexity of fixing things just keeps rising.

Nonetheless, in January 2004, the team finished the first durability build, marking the beginning of Phase Four. Mr. Toppin reflected,

> It is an exciting time but also a tense one. You are working with a lot of suppliers, pushing them to get their parts in on time. Generally, they are producing prototypes themselves rather than working with production tooling, so there is a lot that can go wrong.

Inevitably, the ability to test an actual tractor in a controlled environment revealed more than was evident on paper. While most of Phase Four focused on as many as 1,500 different verification, validation, and reliability tests, there were still opportunities to make variations in design.

After several tests a few months into Phase Four, the team conducted a formal risk assessment, reviewing all design problems yet to be resolved, statistics from field tests, and more. The new engine, transmission, and emissions hardware were not performing at acceptable levels. While the original schedule called for moving forward with a “limited production build” in six months, Mr. Toppin and his colleagues decided to insert a second durability build into the process. The resulting six-month delay was unfortunate but far preferable to taking a risk on an unreliable tractor. The move pushed out the scheduled launch date six months, to November 2005, barely in time to get the product out to dealers in time to meet the Tier 3 requirements set to go into effect on January 1, 2006.

The second durability build proved worth the wait. The engine performed beautifully and, in particular, delivered better fuel economy than anyone had believed possible. The team started quietly showing the tractor to a small number of loyal Deere customers to get additional feedback. The customers loved the variable-speed cooling fan, so Mr. Arntson hyped it in the product literature.

Phase Five was manufacture, and in the latter half of 2005, the Waterloo Tractor Works, a Deere facility on the opposite side of town from the PEC, finalized preparations to make 8030 production routine. It was a time of great anticipation. Cory Reed, who worked out of the Waterloo Tractor Works as head of marketing for the large-tractor business unit, described his colleagues as exuding a “quiet confidence.” Expectations were high as the team prepared to monitor customer reactions closely, ready to respond quickly to any reliability issues. Everyone involved in the 8030 effort understood that even the Deere customers who were always first in line to buy the latest machine were intolerant of “bugs.”

Optimizing Product Development

The gold medal Deere received at Agritechnica was early validation of the 8030 team’s hard work. For the senior management team, it was validation of Deere’s PDP, a process they had shaped and improved over the past decade and one that several Deere executives believed was much better than it had been even for the most recent product introduction, the 8020. Nonetheless, a few executives wondered whether it was the right product development process for the future of Deere & Company and pondered the many delicate balances built into the process.

Listening to the Customer

For decades, Deere & Company was able to operate with an assumption that the company knew the customer very well. After all, most of Deere's employees either grew up on a farm or still operated a farm for supplemental income, or both. The employees and the customers were practically one and the same.

But farm demographics were changing, and changing quickly. Farms were getting bigger and farming more complex, and the number of Deere employees who grew up on farms was slowly declining. As a result, the company invested heavily in formalizing the process by which it pieced together a rich understanding of customer needs. With the help of outside experts, the company carefully segmented its markets and assessed the needs of each segment, employing, for the first time, sophisticated analytical tools, such as conjoint analysis.

By 2006, Deere executives had a common language for identifying customer segments. This was important because the global agriculture market was diversifying. Deere's customer set was no longer dominated by grain farmers in the midwestern United States, as it had been for decades. Deere even created new positions, "customer segment managers," who led the customer research process and ensured that the conclusions the company drew about what each customer segment wanted were rigorous and fact based. The precise role of the segment managers in the PDP was as yet undefined, but their influence was growing, as was the size of their staffs. Part these managers' role was to create new connections across Deere's divisions. The company was organized by product: tractors, implements, etc. The segment managers were to ensure that the combined efforts of the divisions holistically met the needs of each customer segment.

In the course of its market research effort, Deere gathered input from many sources, including its own customer service representatives and the dealer network. But in Mr. Reed's view, nothing was more powerful than focus groups and face-to-face conversations with customers. It took a lot of judgment, however, to interpret what customers were saying. Mr. Markley described his approach to customer interactions:

> You have to listen in the right way, knowing when to take what is said literally and when to look between the lines for a clue to an unmet need. Then, you have to draw connections between those unmet needs and advances in technology that the customer is unaware of. It takes time to truly understand the customer's value equation. Sometimes, you have to talk to 20 customers to get one new insight.

For example, an early clue that contributed to the development of AutoTrac came from a customer who ran a large farm and employed dozens of operators, a few of whom knew they were by far the best at driving in straight lines. They became arrogant, knowing that no matter how badly they misbehaved, they wouldn't be fired. The customer described his problem as employee misbehavior. But the conversation also revealed just how much value customers placed on precise driving and signaled the need for a solution like AutoTrac.

Ultimately, the new focus on rigorous customer research was intended to ensure the company built products that customers wanted rather than advancing technology for the sake of technology or pushing ahead with creative designs because creativity was fun.

While redoubling their effort to understand customers through more formal and analytical approaches, Deere executives were wary of the dangers of listening too closely to customers. Pat Pinkston, general manager of the Waterloo Tractor Works, cautioned that it was easy to overreact to one customer rather than the segment as a whole and that sometimes there was a gap between what customers said they wanted and what they really needed to improve their business.

In addition, being so rigorous about customer needs diminished the opportunity for creative, free-form thinking. The opportunity for creative input always came in the very early stages of product design. Mr. Jim Wienkes, manager of large tractor engineering and product planning, described the environment:

> Everyone has a chance to give their input. You cut people loose and you find out what everyone has always wanted to do. There is never any shortage of energy.

Very quickly, however, the PDP moved into prioritization of a long list of well-known customer needs. Mr. Pinkston described the challenge:

> We have to decide which of many possible features will actually meet customer needs. Our intent is to reduce the number to a manageable few as quickly as possible rather than expending our energies on features that will not end up on the tractor's final design. That's the most efficient way to manage the process.

Risk vs. Return

There was one additional danger of listening too closely to customers, one the Deere team wrestled with routinely. As Mr. Recker put it, "Customers always think incrementally." How could you ever achieve a breakthrough innovation if you were always responding to customers' immediate needs? For example, in Mr. Recker's view, had the original 8000 series design been dominated by direct customer input, there would not have been the free-form, creative experimentation that led to the original design breakthrough.

Mr. Recker was a steady advocate for stretching for bigger innovations. In 2006, he led the technology development process (TDP), a process that ran in parallel with the PDP and was intended to feed it. A few dozen full-time engineers were involved in the TDP, actively seeking breakthrough technologies. Mr. Recker saw grand possibilities for the future, but it was often easier to push new technologies forward on less expensive products where the perceived risk to the company was smaller. The basic parameters for the 8000 series were set, and the company was not likely to gamble on big breakthroughs in its flagship large tractor. Mr. Recker commented on his disappointment in not getting a couple of specific advanced technologies into the 8030 design:

> We make a lot of decisions based on consensus. It takes a lot to get past all of the reasons *not* to do something. So my job is about peeling away the reasons. We didn't get some advanced technologies on the 8030. We were unable to satisfy the skeptics. But we will get them on the 8040.

Many Deere executives viewed Mr. Recker and his team as "a little bit out there." (Mr. Markley was comfortable with that perception, noting that "they are supposed to be a little bit out there.") Nonetheless, Mr. Recker relished the opportunity to be in a position where he was expected to push hard for taking risks on new technologies, even if more senior executives did not always support the level of risk taking for which he hoped.

Throughout the PDP, Deere's management team had to make risk versus return trade-offs, always trying to strike the right balance between the desire to be innovative and the desire to be reliable. Mr. Pinkston elaborated:

> There are several steps in the process that help evaluate the level of risk. It is not generally possible to assess risk quantitatively. It always depends on judgment and experience. If nothing else, we assign risk ratings of low, medium, or high, and impact ratings of low, medium, and high. We have made some mistakes in the past, sending something new into the field too soon. It is very costly. It is costly even to take something up to the point of production before pulling it.

The company did have a few quantitative tools for assessing risk. One of the most straightforward was simply counting the number of new part numbers in a given new product. A typical upper limit for a new tractor design was 35 percent.

Mr. Markley described his view on assessing risk:

> I always tell people that liberal arts majors can indeed make it in business, even in technical areas. I assess risk by reminding engineers of our very low allowance for product returns and then asking hardball questions. God never invented a dishonest engineer. Everything in their training prevents it. The longer they've been around, the better. They are logic *machines*. So when you ask them whether something new will hit a certain reliability goal, a certain quality level, and so forth, their body language tells you everything you need to know. Even if they are passionate about something new, they'll admit it if it is not ready for prime time.

Mr. Reed described the fundamental tension between the TDP and PDP:

> In the PDP, we try to eliminate anything that doesn't meet a documented customer need, and do it early in the process. Still, some of our best breakthroughs come

> from gambles where the customer value is not clear. It only gets harder to take gambles as the tractors get bigger and more expensive. We are, nonetheless, investing in the future—hydrogen fuel, electric drives, steer and brake by wire, even better suspensions—but when is the right time to shoot for a revolution?

Because expectations of reliability were so high, Deere was leery of selling anything to customers that was not fully proven. It was not easy to devise mechanisms for testing experimental technologies. The company did, however, operate a few test fields and had also developed special relationships with a few hundred customers around the world who were willing to work with Deere to test new gadgets. But this could never be a casual process. It was very expensive and had to be done in a way that didn't interfere with the customers' operations, always subject to very tight weather windows for completing critical tasks.

Despite these hurdles, the TDP was expected to deliver a steady stream of breakthrough opportunities. The TDP was loosely defined in four stages: opportunity recognition (considerable interaction with universities, national labs, unrelated industries), research (paper only), concept study (actually experimenting with hardware and documenting potential customer benefits), and folding a new technology into a product (transition from research to development). Quite distinct from the detailed and complex PDP, the full detail of the TDP could be "communicated on about two pages," according to Mr. Recker. (By comparison, according to Mr. Arntson, "There is a whole month's worth of reading about the PDP on our intranet.")

The fourth stage was the most challenging. Said Mr. Recker,

> It's not so bad when the benefits are bigger, better, faster, or nicer. But when the changes are more fundamental or threaten existing products, it is much harder. For example, we're working on a self-propelled sprayer, but that would reduce demand for other Deere products. Even when the business unit is fully behind us, the timing has to be right. The PDP is like a train leaving the station. Once it is gone, it is all about quality, meeting cost and capital targets, and hitting deadlines.

Predictability and Accountability

There were always unknowns in any new product development effort, more so in the earlier stages and even more when relying on suppliers to innovate in parallel. Nonetheless, the PEC team viewed the PDP as a process that could be measured, controlled, and perfected. An upper management team at the PEC met for four hours, once per month, to review progress against schedule and budget.

Chris Myers, director of the PEC, commented,

> We've improved the process with better metrics and reporting. If you fall behind, you get extra help and attention from above.

Mr. Wienkes noted,

> The process is quite predictable. We expect to hit the capital plan perfectly and R&D spending within 5 percent. We know how many resources we need and when we need them. It is entirely appropriate to hold managers accountable, though it does take some experience to make good predictions. You have to understand, for example, that a rookie engineer is only going to be about half as productive as an experienced one.

Mr. Pinkston gave his point of view:

> Our reliability goals for new products are unforgiving. And every step in the PDP is quite predictable in terms of how much time and how much money. We are getting better all of the time. Recently, for example, we called on outside help to set time and budget expectations for software development, which is becoming more and more important in our business.

According to Mr. Arntson,

> We know the exact timing of each step. You can plan well in advance what you will need to be doing and when. The timing has to be accurate, especially when you are under the gun to meet new federal emissions laws. You are out of business otherwise.

And Mr. Anderson added,

> The process is all on paper and everyone is aligned. There is uniformity across divisions—say, between the engine division and the tractor division—and as a result, communications are smooth. Everyone takes the process very seriously. People feel ownership of their role.

Structure

Deere took a cross-functional approach to product development, as demonstrated by the way they organized (see Figure 2, Organization Chart). As product development efforts were of finite duration, Mr. Toppin's staff was composed of people "on loan" from permanent posts, from the staffs of Mr. Pinkston and Mr. Myers.

For the duration of the 8030 project, Mr. Toppin had full-time managers in each function reporting to him. (They also maintained a "dotted-line relationship" with their existing managers.) The arrangement had evolved over time from an earlier one in which the functional leads on a new product team maintained their full day-to-day responsibilities while also supporting the new product development effort. As the company perfected the PDP, it seemed clear that a full-time, co-located team was a necessary ingredient for success.

The dual-reporting arrangement created some conflicts, described by Mr. Toppin:

> The function heads do not want to give up good people to a full-time product development effort. We work hard to maintain continuity by collaborating on performance reviews and freeing up enough time so that people can attend their regular staff meetings. It is working. People are rotating in and out of product development without too much difficulty. The function heads can see that the talents of their staff are being utilized in an appropriate way.

In Mr. Toppin's view, you had to have decades of experience before you were ready to manage a new product effort. You needed first to live through the process more than once, and each iteration was a multiyear effort. "Over 10 percent of my career is on the 8030," Mr. Toppin reflected. You needed to have a strong network of relationships and be able to make accurate assessments of time and resources to complete specific tasks.

Mr. Toppin also had to focus on the big picture, and here experience helped less. Engineers, in the course of product development efforts, tended to specialize in specific components. As such, Mr. Toppin had to ensure that the efforts of dozens of specialists aggregated to a cohesive whole.

Perhaps the most challenging aspect of the process was the transition from the product development team to the ongoing operations team. That required frequent coordination, particularly with the manufacturing group and supply chain teams. The management team also employed a strategy of keeping at least two-thirds of the development team involved with the product for at least six months after launch. The new product team was not simply disbanded once the design was complete. Beyond six months, there was a high probability that the handoff issues were resolved and the ongoing operations team could focus their efforts on routine continuous process improvement.

People and Culture

Every newly hired employee of the Waterloo Tractor Works, from the management level to the front lines, spent 90 minutes with General Manager Pat Pinkston, talking about why Deere is a unique company and discussing the company's four core values: integrity, innovation, commitment, and quality. Mr. Pinkston elaborated:

> I have 3,700 employees here, so the 90-minute conversations are a big commitment. But they are important. There are a lot of demographic changes in our workforce. We can no longer expect our values to transfer through osmosis. Everyone has to live up to the old John Deere saying "I'll never put my name on a product that does not have within it the best that is within me."

Mr. Myers reinforced the importance of these core values:

> We succeed because people are honest and conscientious and because they have strong ethics. We put everything on the table. There is no hiding here.

Making innovation one of four core values signaled the senior management team's view of its importance, and it affected how executives spent their time and shaped their career ambitions. Mr. Pinkston spent roughly one-third of his time working on new products. "We can only help our customers become *more* profitable by innovating," he commented.

Many Deere managers strove for assignments on new products. To get them, they needed to demonstrate deep expertise in a particular component—or unusually high creativity. Demonstrating some proficiency in three different kinds of innovation (continuous improvement, product development, technology development) accelerated promotion. (In addition, to reach senior levels, a manager needed cross-functional experience, including time in factories and time overseas. Deere built such rotations into career plans.)

The company also rewarded innovation breakthroughs and patents with internal awards, given through a worldwide engineering network. Such awards certainly increased influence, though they were not directly linked to promotion or compensation. Bonus pay was tied to the entire agricultural division's performance rather than that of a particular product or project.

In recruiting new engineers, Deere & Company benefited from a strong campus reputation, particularly on engineering campuses in the midwestern United States. Historically, many Deere engineers had grown up on farms, and many had a genuine passion for tractors that sustained them for decades-long careers in one company. They had an innate curiosity about machines and how they could be improved. They enjoyed seeing the tangible results of their work in the form of large and complex pieces of heavy machinery. It was a source of pride for many to be able to return to the town where they had grown up and tell friends that they helped develop John Deere tractors.

But it was getting harder and harder for Deere to rely on this profile for new hires. As the number of small farms shrank, so did the number of engineering graduates who had been exposed to farm life during childhood. The company was finding it had to work harder in recruiting.

Throughout the 1990s, Deere also faced the challenge of building new competencies in electrical engineering and computer science. In fact, the company explicitly reshaped the PDP to enable the electrical engineers to have more input at the front end of the process where they could have greater impact. The transition was not natural. The mechanical engineers had pride in their discipline and had traditionally held all of the positions of power.

Most of the electrical engineering hires came from the same target engineering schools. To recruit, Deere emphasized the importance of innovation and surprised candidates with the ubiquity of electronics on modern tractors. The company also established an enterprise-wide electronics group, pushing forward electronics solutions that had potential application across all product platforms. That group attracted highly talented applicants.

Mr. Markley commented on the task of integrating the new skill set:

> It took a while for electrical engineers to gain status. But smart ones made an impression quickly. At Deere, if you get the basics right—you show up on time, you look professional, you act respectfully—you start out with a positive bias. Electrical engineers who did that *plus* identified solutions to problems that had yet to be solved—and many had opportunities to do so—moved up quickly.

The personnel profile at Deere was interesting. There was a large group of very experienced managers and engineers who had come to the company prior to the 1980s downturn. Then, there was a much younger group, with less exposure to farm life but more exposure to the engineering disciplines that were growing in relative importance. In some groups, such as the information technology–focused agriculture management solutions group, average tenure was less than five years.

Innovation, the PDP, and the Future

Deere executives recognized that the PDP was not the formula for bringing every innovative idea to market. They wrestled with ways to simplify the process for smaller product-development efforts, for example, and succeeded in launching an innovative scraper with new automatic controls in only eight months.

Pressures to remove administrative hurdles built into the PDP were sometimes heavy, but the company removed those hurdles cautiously. While at first it did not seem to make sense to follow every check and balance in the PDP for a tractor that cost one-tenth as much as the 8030, those low-priced tractors sold in much larger volumes and thus the risk to the company's reputation and bottom line could be just as big or bigger.

The PDP was recognized for what it was: a disciplined routine for delivering new products that today's customers quickly recognized they valued. It was not a process for building new businesses.

Nonetheless, as the industry evolved, it became clear that Deere would have to operate differently in its increasingly distinct customer segments. And, as information technology played a greater and greater role in the industry, Deere would have to consider new business models. As Mr. Markley put it, "Products will have even more electronics in the future. We need to figure out how to maximize the value of information. That is the company's main challenge now. "

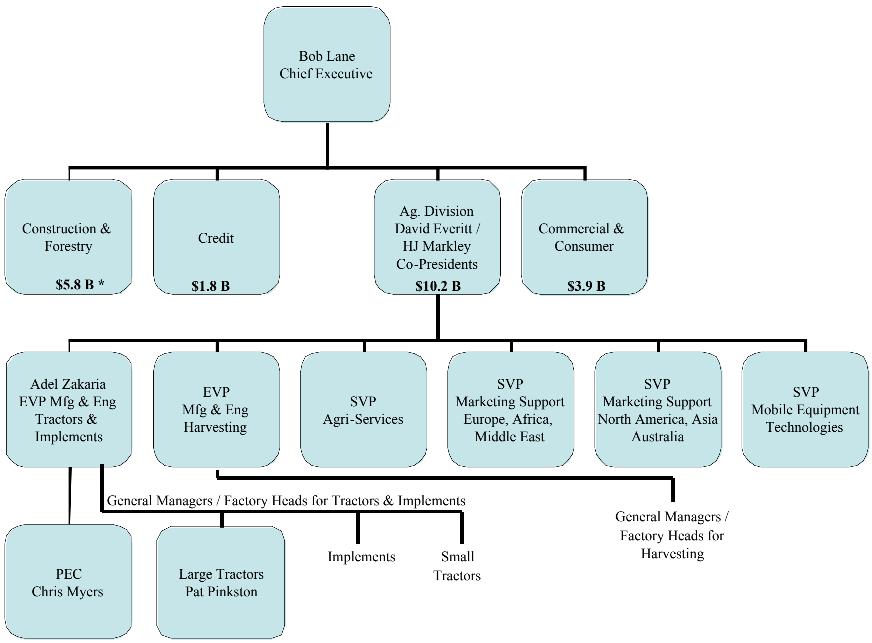
One Year Later

The market response to the release of the 8030 tractor was positive. Independent testing proved that the fuel efficiency had improved 9 percent, despite the necessity of meeting Tier 3 standards. In fact, at an independent test lab in Nebraska, the tractor set a record for fuel efficiency in large row-crop tractors. Furthermore, Deere & Company accumulated several additional awards beyond the gold medal from Agritechnica, including one that named the 8030 "tractor of the year" in Europe.

Sales exceeded expectations, and Deere's market share in both North America and Europe increased throughout 2006. More customers than anticipated purchased the infinitely variable transmission and reported strong satisfaction with the new feature, confirming its value. Customer satisfaction scores indicated substantial improvements over the 8020 tractor. As of early 2007, one year after launch, customers had noted no significant reliability issues.

The product development team had begun early stages of the 8040 design. The feedback from users of the 8030 tractor validated what they already knew: customers cared about reliability, power, efficient operations, and comfort. But the team also knew that to stay on top, it would have to consider breakthrough developments for the 8040, perhaps breakthroughs in information systems or possibly a capability to burn biofuels.

Figure 1: Organization Chart



* Note: Revenue figures from 2006 Annual Report

Figure 2: Organization Chart