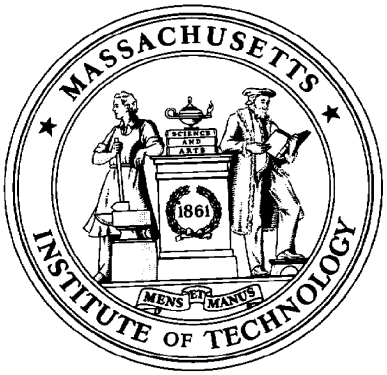

LEAN 94-04

Manufacturing Change at the John Deere Harvester Works

Report on the Visit of the Ad Hoc Lean Aircraft Initiative Team June 7, 1994

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Date of Report November 1, 1994

Acknowledgments

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Overview of Manufacturing Change at John Deere *

Why Did We Visit John Deere?

Results from the Lean Aircraft Initiative (LAI) confirmed that none of the participating manufacturers were achieving significantly efficient manufacturing performance. Some firms are taking aggressive action to change production operations. But so far, there are "no Toyotas" among us. Representatives of the aircraft producers participating in the Initiative concluded that they should investigate manufacturing outside the aerospace industry in their search for practices that would help improve factory operations.

The John Deere Harvester Works in Moline and East Moline, Illinois, a component of Deere & Company, was and is nationally known as aggressive and successful in changing manufacturing. It has achieved significant improvements in productivity and product defects. After a preliminary visit by the author, the general manger of John Deere, Dick Kleine, agreed to host an LAI visit.

On June 7, 1994, seventeen representatives from the Initiative traveled to Deere. The group included thirteen representatives of nine aircraft producers, two members of the MIT LAI team and two members from the USAF Manufacturing Technology Directorate, Wright Laboratory, Dayton. Their names are in the first annex. The present writer organized the effort.

Benchmarking Method

A version of *informal benchmarking* was used by the visiting team. In this method, a team of (manufacturing) experts investigates a target facility. The educated eyes of the specialists see achievements that are noteworthy in the context of their home operations. Identification of significant accomplishments and diagnosis of the reasons for the observed higher performance are principal outputs of such a benchmarking visit.

Formal benchmarking, with its emphasis on metrics and before-the-fact development of questions, is suitable for situations wherein comparisons can be well structured before a visit, for example, between similar operations in comparable enterprises. Informal benchmarking seems better suited for comparisons of operations

* The John Deere Harvester Works is an operating unit (i.e., profit center) of the corporate entity Deere & Company. In this report we shall refer to the Harvester Works as *John Deere* or simply *Deere*.

across dissimilar enterprises. It quickly focuses on important achievements as they are encountered during a visit.

The entire LAI team helped collect data. Each of the seventeen participants was assigned an area to investigate and a form that asked for (a) an outline of Deere practices, (b) judgments regarding the suitability of those Deere methods for the U.S. aerospace industry, and (c) any opinions about the aptness of other Deere approaches for the manufacture of aircraft. The second annex lists the seventeen subjects of investigation and shows the form that was used.

This report is based on the collected observations of the seventeen LAI representatives.

The LAI participants were also asked for suggestions on how John Deere could further improve its plant operations. Those were collected and forwarded to Deere & Company.

Manufacturing Change Arose From Deere's Distress

Going into the nineteen-eighties, John Deere enjoyed a good business. In the mid-eighties, the market for agricultural equipment collapsed as economic recession hit many farmers in the US. Deere's business was cut more than in half. It survived by tightening its belt. It now has 35,000 employees, down from 67,000. Of a dozen producers of agricultural equipment in the US in the early eighties, only Deere survived intact.

Beginning in 1990, the John Deere Harvester Works, which makes planters and combines, made massive changes in its production operations to improve productivity and customer satisfaction. Consequently, John Deere has significantly improved its business position over the last four years. Although a number of factors contribute, Deere & Company had record financial results for the first three quarters of 1994. The Harvester Works as well is having its best year ever.

Once known as an expensive producer of high quality products, Deere successfully changed its image and practices to those of a responsive enterprise attuned to its dealers and customers and with a competitively priced product. It retains its reputation for quality.

Products of John Deere Harvester Works

The most complex product of the Harvester Works is the combine. It has 15,000 parts distributed among 5,000 part numbers, 55 percent of the value of which is purchased from suppliers. Weighing well over 20,000 lbs, depending on model, it is arguably one of the most

complex products in series production outside of the aerospace industry.

John Deere manufactures more than a dozen combines each working day. They come in several models with a number of optional features. Prices to the farmer range typically from $150,000 to $190,000.

Less expensive is the planter at $45,000 for the 12-row. Towed behind a tractor, a planter places seeds and agricultural chemicals in the ground at precise rates. Planters are sized by number of rows planted simultaneously, from 4 to 24. With other options, the number of different planter configurations is in the millions.

A planter is less complex than the combine with a third the number of parts. Production rates are comparable to those of combines.

Figures 1 & 2. John Deere Combine and Planter

Overview of Factory Operations at John Deere

Planters and combines are manufactured in separate factories respectively at Moline and East Moline. The team toured and was briefed on both factories. They are under the management of Mr. Dick Kleine, who as general manager hosted our visit. Because Kleine is the principal source of the vision and motivation for manufacturing change, operations at both factories are organized according to similar principles. We give an overview of the planter factory here because it is simpler.

The planter factory is organized into ***modules***, each of which is an independent "factory within a factory." Every module has the resources, skills, machines, machine maintenance people, tool builders and control of suppliers to fabricate and assemble a major subassembly of a planter. The planter factory has half-a-dozen manufacturing modules which build

Frames	Drives	Planting units
Lifts	Markers	Fertilizing devices

as seen in the plan view of the factory in Figure 3 (next page).

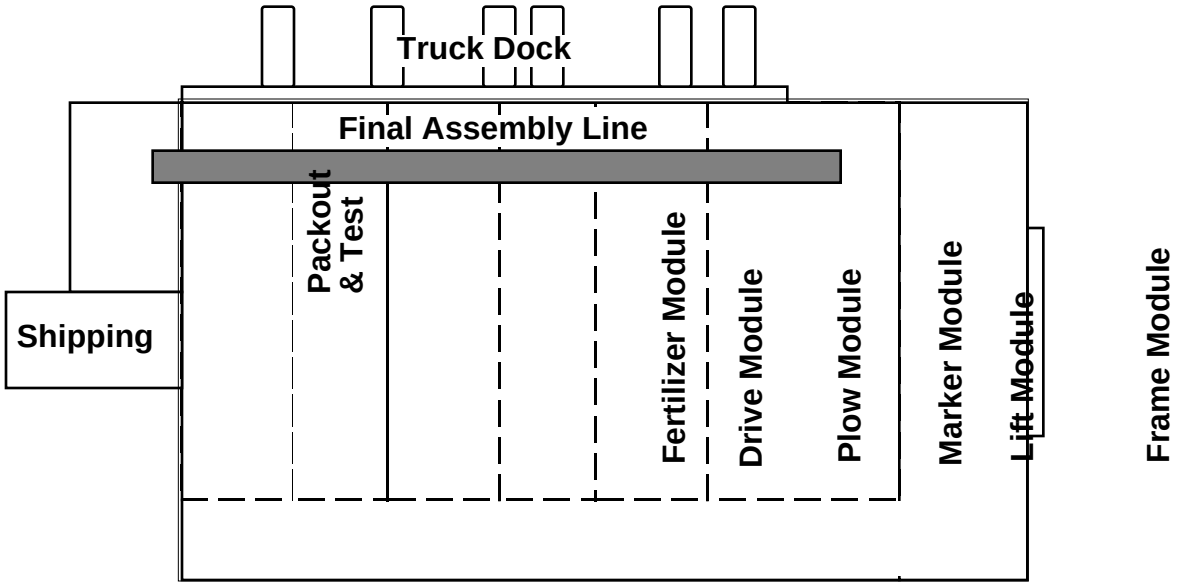

Figure 3. Plan View of Planter Factory Showing Modules

The modules are located directly next to the assembly line. Consequently, parts are manufactured and subassemblies are assembled right next to final assembly.

This tight coupling between operations is intended to place internal producers and suppliers in close proximity to facilitate communications, minimize inventory and transportation times, and make the production process visible. The coupling in the planter factory is tightened further by the absence of final assembly line workers. The module workers not only build the sub-assembly but fabricate many of the detail parts but also install their subassembly product onto the planter. Consequently, if there is a problem in final assembly, there is immediate corrective feedback to the builders of the subassembly.

Final assembly is accomplished on a mixed model or “homogeneous” line. Various models of the planter, with ordered options, go down the line in delivery sequence. Model runs are eliminated. Previously, yards around the factory were usually filled with a couple of hundred planters because production was organized into annual model runs. Now the yards are empty. Finished planters are picked up and shipped “just in time” by dealers’ trucks or commercial truck lines.

Several truck docks are located on the north side of the assembly line. There, workers pull certain purchased parts, such as wheels,

from parked trailers loaded by suppliers in model production sequence. Raw material for modules is delivered daily to the factory in a “just in time” fashion. Raw stock arrives on the east dock and is staged through the east end of the factory.

Supplier control is divided into “strategic” and “tactical.” The former is handled by office people. They prepare basic ordering agreements, typically for a year. Tactical control is exercised by people, often union, who are in the receiving module. The module workers order weekly deliveries based on production plans prepared in the combined *order taking* and *shipping* module. The shop floor workers also adjust weekly deliveries and iron out problems with suppliers directly.

The John Deere Production System

Even with this cursory overview, the basic ideas behind manufacturing change can be seen. Concepts of plain, minimal flow and module independence pervade the approach to work in the two John Deere plants. Self-sustaining modules operated by empowered teams of workers place the responsibility for manufacturing improvement and problem solving on those doing the work, the key to real continuous improvement.

Opportunity alone will not effect productivity improvements. There must be incentive too. Deere has addressed that on two counts. First, Deere has a job security plan for all employees. Improvements to factory processes will not put anyone out on the street, white or blue collar. One Deere plant has over one hundred excess salaried employees, a surplus awaiting natural attrition. A special early retirement program in October will reduce this excess to thirty.

Secondly, Deere shares productivity gains with its workers. The value of each week’s wages depends on weekly productivity and quality. The base hourly salary is $16.50. Incentive pay can increase that by up to 45 percent on a weekly basis.

Every six months, workers at the planter factory are rewarded if there were significant, longer-term productivity gains beyond the weekly 45 percent. With each award the threshold for the next award is raised. At the end of each of the last two six-month periods, for example, the workers in the planter factory received pay for a banked $7^{1}/_{2}$ percent productivity improvement (plus a matching bonus) while the man hour “chinning bar” was raised $7^{1}/_{2}$ percent. The net result in the year-long period was a permanent reduction of direct labor cost by15 percent.

Philosophy of Factory Operations

The heart of manufacturing change at John Deere is equipping and guiding every individual to improve his performance, beginning with the mission each person commits to. Kleine said some companies have statements of mission that are too complicated for people to understand. He believes in a simple mission:

To Please Our Customers

for every person in the factory, whether his or her customers are inside or external.

Kleine is more than a cheer leader. He helps his people acquire the tools to please their customers. As Deming and Juran have taught us, posters that say things like "Quality" and "Zero defects" are equivalent to exhortations to "row harder." In contrast, Kleine and his managers formulated three specific principles that are instructions for achieving change that leads to greater productivity and customer satisfaction.

Density—Minimize space between machines

The Deere people use this principle in an unusual way, as a weapon to eliminate room for storage of work-in-process (WIP). Deere is presently at 60 percent density (space occupied by machines divided by module area). Its managers believe they can and should achieve higher densities. By the way, union people had a big hand in locating the machines in the present arrangement.

Flow—Locate processes at point of use

This principle makes for good communications between producers and customers, enabling quick identification and solution of problems and, consequently, continuous process improvement. Cycle times, WIP, and loss and damage of parts are reduced by shorter material handling distances. In the combine factory, for example, some parts used to travel for tens of miles before reaching final assembly. Now those distances are down to feet.

Velocity—Process parts on demand using a pull system

This principle also lets problems be solved quickly and cheaply because workers in a module do not have to deal with a large inventory of WIP when they change their processes. Higher parts velocities reduce cycle times and WIP inventory and increase inventory turns.

The practical effect of organizing production according to the principles of *density*, *flow* and *velocity* is to drive down lot size, set

up times and WIP. Perhaps more importantly, all aspects of manufacturing become more ***visible***. Waste is more quickly seen and analyzed. Actions not adding value are more apparent and can be examined carefully. It is easier for people to work together to achieve continuous improvement.

One last point. The management at John Deere does not use the words “lean” and “efficiency”. It refers to “manufacturing change” to carry the sense of many benefits. We suppose that those words were carefully chosen to avoid the idea that everybody can rest once they achieve a certain goal. Manufacturing processes are continually faced with changes in their environments, new equipment, new products and new demands on their performance. Consequently, change is required just to “stay even,” let alone overtake competitors. The people at Deere have rightly institutionalized change, with one motivation being to achieve higher productivity. We saw only two slogans on signs at Deere. One was

Change = Success

(The other slogan will be mentioned later.)

A Deeper Look at Manufacturing Operations

Worker Teams Control Modules

More module independence is needed to enable continuous change. Worker teams must have control of their processes. Plant management has given each module all that they need to manage their production:

- Dedicated machines
- Dedicated tool repair & preventative maintenance
- Dedicated tool builders
- No external computer control pushing parts
- Pull system
- Tools and auxiliary equipment
- Tactical supplier management
- Quality control
- Dedicated design engineer
- Team training
- Cross-training
- Minimized external communications

Each module has dedicated machinery. This ultimately requires more machines than the traditional sharing of machines organized functionally and results in lower machine utilization. The tradeoff is however that the module *only makes what it needs when it needs it, and does so quickly*—with negligible transportation times and minimal costs due to lost or mis-routed parts. Assembly workers no longer suffer from operations done by distant functions with little interest and knowledge of the specific needs of the assembler. On top of that, immediately proximate fabrication at point of use enables direct and quick correction of problems between fabrication and assembly.

Small machines are intermixed with large machines. Workers can do small tasks while big machines are running.

The modules are completely self-sufficient except for payroll, advertising, marketing, product development, and financial. Even the plant management does not control the modules. It sets goals, performance metrics, and formulas for pay incentives. Consequently,

the module team is fully in charge of the process and its improvement.

This is a powerful concept. Tied to a productivity incentive system and a job security policy as it is at Deere, this approach to worker empowerment and elevation enables continuous process improvement.

The sense of independence is supported by the five stages of team building. With training, each module advances to the fifth and final stage: a completely self-directed team. Further, each module must strive to become a certified John Deere supplier.

Culture

Values, traditions, and "the way we do things around here" are elusive elements that have to be right for people to change the way they work. As many companies have sadly found, existing practices have great inertia. But a shift in a company culture is crucial to change for greater productivity. A company's bottom line will not respond to productivity initiatives unless its people are in the right frame of mind to accept change and make it work.

The spirit of change is strong at Deere, as the consequence of a number of interlocking actions begun two years ago.

Elevation of the worker—Wage workers are treated with respect and given additional responsibility. Their assistance with machine layout has already been mentioned. Wage workers participate in product development teams, benchmarking at other companies (sometimes on a union-to-union basis without non-union supervision), and visits to farmers to understand customer viewpoints better. The factory worker is listened to and solicited for inputs for change. Putting the workers in charge of what they are doing in their modules is a significant step. The people we interviewed were enthusiastic about their jobs and the responsibility and authority they had.

One story is indicative. A tool maker in a module in the planter factory said that he had hated working at Deere. Employees were commanded, not consulted. Now, he can hardly wait to come to work each day. The new culture has changed his life and his attitude of Deere from night to day. This man, a union member, is letting contracts for tools. Without the need to ask permission, he leaves the premises as required to visit his contractors. He has independence and freedom to do what is necessary to help achieve the overall goals for improvement laid out by the management for the modules.

This page may contain information proprietary to Deere & Co.

Management Oversight—Management is by results. Factory goals are set and shared with all employees. Each module sets their own goals in support of factory goals.

Training—Formal instruction not only changes the way people think but also equips them to know what to do to effect constructive change. John Deere pays for a lot of training for its employees. On the average, each John Deere employee gets 29 hours training annually. The goal is 28 hours per year. Each employee has an individual training plan.

Deere has a core curriculum that all employees are required to master. Its three components are

- Business (e.g., manufacturing change, activity-based costing),
- Social (e.g., interpersonal skills and team building), and
- Technical (e.g., CAD/CAM, blue print reading, numerically controlled machining).

The business unit manager will attend 140 hours; the module leader 140 hours; and the module team members 84 hours each.

Deere has a training curriculum of 200 courses taught by 10 full-time instructors, both salaried and union. In the product development area, experimental shop workers are required to complete courses at local community colleges to reach the highest labor grades.

All training at the behest of the company to improve skills is on company time. Training opted for by an employee to improve his or her "promotability" is on the employee's time.

Job Security—To create cultural readiness to change, John Deere management struck a deal with its unions to give job security. Union employees can only be laid off eight weeks per year. As an illustration of Deere's commitment, it carries over a hundred superfluous white collar workers who will not be replaced as attrition lowers their numbers. The LAI visit team believes that job protection is critical to institutionalizing a culture of change.

Pay for Productivity and Quality—The visit team concluded that a major factor in encouraging continuous change is that John Deere shares productivity and quality improvements with its workers. Workers are given a weekly pay component based thirty percent on warranty performance and seventy percent on productivity.

The planter factory has a "gain sharing" program. The hours actually worked in the factory are compared to a standard number of hours

to produce a model planter, multiplied by the mix manufactured each week. When each planter leaves the end of the line, the factory workers are credited with the standard number of hours and a quality component. They are paid the difference between the total of the standards and their actual total weekly hours.

That is, up to 45 percent improvement in productivity. The hours short of or beyond 45 percent are "banked." Every six months, the net banked hours are examined. If the equivalent productivity gain exceeds $7^{1}/_{2}$ percent of the standard, the workers are paid double the saved hours and the standard hours per product type are reduced by $7^{1}/_{2}$ percent. Both John Deere factories have incentive payments. Only the planter factory has the plan to "buy down" standard hours.

As a consequence of these sharing plans, there are strong motivations to improve product flow in the factories. Workers have genuine incentives to improve their processes. Consequently, they work hard, as we observed on our visit. People who were asked to discuss Deere's changes with the visiting team were often out of breathe from hard work as they left their work stations. At other points in the plants, fellow workers moved to fill for individuals who were temporarily pulled away from their tasks to talk with us. No question about it, the workers were laboring hard to keep productivity high because their efforts put money in their pockets.

The data we saw (presented in the *Metrics* section following) confirm Deere manufacturing productivity.

Management Interest—The general manager is never to be found in his office on Fridays. He spends it in the plant talking to the workers. This habit is a powerful expression of the value of the workers to the management.

External Customer Orientation—To improve the satisfaction of Deere's customer, the management and workers started cultivating dealers and customers. Dealers were brought in to help tear down newly manufactured equipment as part of Deere's weekly quality audit. Deere management, often Kleine, calls customers who have warranty or other problems. Customers are brought to watch their combines being built and to start their combines for the first time with gold keys. Blue and white collar workers visit users and dealers. In short, one finds an aggressive program to listen and learn from the outside world, a cultural shift from the old Deere.

Back to the Wall—Deere managers admit that the desperate business situation to which they were responding was in itself a great motivator of employee receptivity to change. The Harvester Works

had already lost a majority of its work force by the time management began its campaign of change. As with many other firms that made significant steps toward the Toyota production system, it was either change or go out of business. Consequently, the union (UAW) granted flexibility on work rules and supported massive re-organization of how Deere produces equipment. Although survival issues may have been an important component of the motivation for change, we believe the work force is now solidly behind Kleine's program on its own merits.

Suppliers

Over half the value of John Deere's products comes from outside suppliers. Deere has several initiatives to improve their efficiency.

- Deere is forming deeper, quality-based partnerships with fewer suppliers. Already the base has been cut from 1150 companies in 1987 to 689 companies, with a goal of 640 by the end of 1994. Those remaining participate in Deere's supplier certification program (just as do the internal "factories") and are moved to long-term contracts.
- Deere teaches its suppliers about its approach to manufacturing change and pays for the training. Deere uses quarterly supplier councils to deal with common problems.
- Most raw material is delivered daily to the factory daily in a "just-in-time" fashion, with one cut made by the vendor.
- Other material, such as fasteners, are delivered to the floor on a cycle that ranges from twice daily to weekly, depending on material value and usage rates. A "kan ban" card system is used.
- Some supplied equipment or parts are, as noted previously, delivered in trailers parked next to point of use. Inside each trailer, parts are loaded so as to be withdrawn according to a week's sequence of building models.
- Despite the intent to minimize inventory, factors such as production rates and part values make it wise to use methods of supply other than closely tuned just-in-time. For example, Deere uses a truck that makes a weekly "milk run" through the Midwest to pick up parts from suppliers.
- Similarly, some parts are purchased in large quantities and warehoused near Deere plants for delivery on an "as-needed" basis.

- Suppliers are required to pay costs warranty claims for which they are responsible.

Work Rules

Deere workers are organized principally by the UAW. Two small chapters of the IAM are also present. Unions, recognizing a coincidence of interest in Deere's survival, cooperated with Deere's management in putting flexibility into work rules and organization of work. The union members have benefited in turn by a policy of job security and more stimulating and rewarding work.

The local union leaders have not negotiated away the couple of dozen job classifications. Nonetheless, workers are permitted freedom to work across job classifications and many are cross-trained to do so to give module leadership the flexibility to move labor to the job at hand. We saw one woman, classified as a welder, setting up a multiple spindle drill press, then driving a fork lift to bring material to her work area. Finally, she did some welding while the drill press remained in operation.

Workers log change of tasks so they can be paid for the work they do.

Inventory and WIP

Relocating operations next to point of use, increasing machine density and giving each module the dedicated equipment it needs for its manfacturing operations significantly reduced WIP. Computerized control of work external to the modules has been replaced by physical signals in a "pull" system. Kan ban carts sized to a day's production are used to control many fabrication activities adjacent to subassembly operations. Most material movements are over short distances. Manually moved carts have been introduced to replace motorized equipment. The number of fork lifts and trucks in the factories has consequently dropped by a factor of five, indicative of the impact of the new inventory management policies.

The second slogan we saw on signs at Deere was

Inventory is evil

Quality

Workers self-inspect their work. The incentive system motivates them to avoid quality problems and to keep production rate up. We detected a sense of not letting down one's fellow workers by making mistakes or producing poor parts or subassemblies. Workers recognize that defects reduce their and fellow workers' weekly pay.

The management has two principal quality checks. At the end of final assembly, each planter or combine is given an inspection that does not involve disassembly. If it passes, it is moved onto a dealer's truck and the factory work force is given credit for the standard number of hours for the particular model. Those hours tie into the weekly incentive pay and the semi-annual exercise of the gain-sharing plan, as explained in the foregoing.

Once a week, a randomly selected planter and combine are given extensive, three-day, tear-down inspections. Both dealers and wage workers participate in this inspection. The purpose of this inspection is to improve processes so that revealed problems are avoided in the future.

The Deere product development function is involved in the quality process. Each module has a dedicated engineer from product design whose job is to bring engineering expertise to problems in the factory. The design function has responsibility for manufacturing defects and deals with warranty claims. Modules give feedback to product design for future design and manufacturability improvements.

We were struck by the degree the Deere production system depends on self-inspection. It has only six audit inspectors across the 3,000-person force. To our surprise, the Deere people use very little statistical process control. Apparently, their low rates of manufacturing defects spring from the highly capable manufacturing system Deere has in place. They design robust processes that stay in control. In other words, a quality process produces a quality product.

Avoidance of Computers

Deere people showed an aversion to use of computers. Certainly they are used for certain functions. For example, factory simulations are used to help design new factory flows. Also computer programs (e.g., MRP) do week-at-a-time production planning to let module teams plan their work and order from suppliers.

But we saw few computer terminals in the factory. The use of computers to control factory processes in real time is shunned, apparently because it was perceived as depriving workers in modules of full control of production. Also, computers are not used when the manufacturing process is simplified.

The main idea here is that central computer control takes control of shop floor processes out of the hands of the people doing the work and therefore damages effective and continuous process improvement.

Avoidance of Paper

Aversion to unneeded control information seemed to extend to paper. We saw surprisingly little paper in the factory. Paper work instructions are provided for each operation. But few computer-produced status sheets were to be seen. Reports and travelers were no where to be found.

The absence of paper is no doubt attributable in large measure to the relatively high production rates. Workers learn to do fabrication and assembly tasks without reference to instructions or drawings.

But Deere principles of manufacturing change must be partly responsible too. The use of kan ban in a pull logistics system eliminates much paper. Locating production processes at points of consumption also reduce paper transactions by promoting direct, spoken communications to solve problems.

Some small details seem too trivial to make a difference but in aggregation have noticeable benefits. As just one example, the machines and boundaries of each module have a distinctive color. As a consequence, when a machine is moved out of its module for major repair, no paper work is required to route it back to its home. Its color shows its return destination.

As an intangible effect, color helps teams identify with their modules.

Product Definition

Products are designed by an integrated product definition team, a core of designers supported by manufacturing engineers, purchasing people, reliability and test engineers, and shop supervision. Even union wage workers are on development teams.

When a significant new product is introduced, the first model is built in the lab. Then the next several prototypes are built on the production line. By the time the model comes into series production, the workers are already familiar with it. Besides having had some inputs into producibility of the product, they will have had some practical experience with its manufacture.

Product design teams have good visibility into product performance, both in production and in the field, since they deal with defects using a defect tracking system and are responsible for dispositioning warranty claims.

Metrics

John Deere management has developed a set of measures of operating performance involving flow times, inventories, unit costs, some supplier information, safety, final product audits, warranties, internal and external customer survey results, and production among other factors. It uses these data to create a composite Measure of Success, to set annual goals for improvement and to monitor plant performance. Short-term process measurements or controls were not evident.

The LAI team's interest was a little different. We wanted to see measures that would show whether there were significant productivity improvements associated with manufacturing change. Here's what we saw.

- 30% less inventory than in 1990 and 70% less than in 1979
- Inventory turns at 12 per year
- Raw material and WIP down from 50 in 1979 to 17 days today; goal: 15 days
- Cycle time reduced 46% in parts manufactured from raw material and 42% in materials purchased complete (September 1992 to May 1994)
- Salaried work force down 20% since 1990
- Material handlers down from 200 to 80 over the last five years
- Warranty costs down 22% since April 1992 (planters and combines)
- Warranty claims per planter down 30% since 1990 to today
- Sales per employee per year up 55% since 1992
- Tons of product per employee per year up 44% since 1992
- Combine manufacturing floor space down 20% due to focused operations
- Planter floor space down 55% due to focusing

- Flow times for combine components:

Component	Factor Improvement in Inventory Turns
Cylinder	8 (17 weeks reduced to 2)
Beater	15 (15 weeks reduced to 1)
Concave section	6 (30 weeks reduced to 5
Shaft	10 (45 weeks reduced to 4)

- Levels of management from 7 to 4

As in the Toyota production system, reduction of tool set-up times are viewed as a critical part of reducing cycle times and WIP. John Deere attacked set-up times by dedicating machines to a process, sometimes even by buying used equipment. Eighty-four percent of machines in the planter division have change-over times of 5 minutes or less. The remaining machines are being addressed to reduce their change-over times to the five-minute goal.

Deere notifies dealers to pick up a combine ten days in advance of its delivery. Then, five days before the scheduled pick up, the Harvester Works begins building the machine. The final day and a half of cycle time is final assembly. The total five-day cycle time compares to eight days three years ago.

Deere intends to improve cycle times by a factor of ten by the year 2000. To reach that goal, management has set a goal of reducing cycle times by 30 percent annually.

The management also intends for John Deere to become a “6-sigma” company in the sense that Motorola has used the concept to guide its quality program. To reach that goal in five years, Deere has set itself the task of reducing its defects by 50 percent each year.

Lessons for Aerospace

The members of the team representing the Lean Aircraft Initiative were individually asked to recommend practices observed at Deere for applicability to the aircraft industry. Their responses were tabulated and are listed here along with some team comments. The number of "bullets" indicates the strength of the response from the survey team.

1. Modules•••••••••

Greater use of modular manufacturing, skill interchangeability, worker empowerment, self-directed teams, and minimum management supervision on floor. Workers have responsibility, authority and accountability for process improvement. Dedicating much machinery may not be practical at low aircraft rates, but product grouping of machinery by part families may be and should be beneficial.

2. Emphasis on inventory reduction•••••••••

Production process policies that aggressively attack excess inventory. Use of pull production. JIT and kan ban ought to be applied to inventory management and supplier relationships. How should Deere policies be modified for low rates seen in aircraft industry?

3. Training•••••

Extensive and thorough worker training is essential for culture change and equipping workers to function in empowered teams. We all should have a goal of 30 hrs/yr exclusive of technical training.

4. Focus on work flow•••••

Looking at technology solutions to achieve manufacturing efficiencies before looking at production flow is putting the cart before the horse. Organization and management, not technology, are the keys to productivity.

5. Battle cycle time••••

Use cycle time reduction concepts pushed by internal pressures. Annual goals ought to drive us.

6. Gain sharing and wage incentives••••

Sharing company gains in efficiency due to process improvements seems not only fair but essential to secure cooperation of unions and serious worker involvement

productivity improvements. Economic incentive and job security are sisters to worker team empowerment for continuous change. But such a system must be fair and equitable to all employees in a company.

7. Set-up time reduction•••

This is important for small lot sizes, short cycle times, multiple model production, and minimal WIP in any company.

8. Leadership•••

Visionary, revolutionary change must be driven from the top down. The LAI team liked the leadership qualities of Deere's plant manager, Dick Kleine, and his team from whom the vision for manufacturing change at Deere flowed. Without that vision, Deere would probably have failed to change. It is difficult to overrate the importance of leadership vision in making radical change in an organization.

9. Customer focus•••

Exposure of people at every level to the customer and the searching out of customer inputs would benefit any industry.

The following items were mentioned twice or once:

••Activity based costing; inventories chargeable to cost center.

••Benchmarking. Extensive and continued use of benchmarking.

••Customer surveys.

••Density—Emphasis on higher density of machines on floor. Closer spacing drives process efficiencies and inhibits build-up of inventory.

••Integration of design engineering. Integrated product process definition (IPPD).

••Standard design features--radii, bends; standard raw materials types and thicknesses, all to save set up times.

••Subassembly workers do installation of their component in final assembly.

••Worker empowerment and involvement in both planning and operations.

•Data reduction programs to reduce paper on shop floor.

•Few but specific goals—e.g., defects down 50%, cycle time down 30%.

•Mistake proofing.

- Multiple models on same line.
- Reduced levels of management.
- Sampling inspection.
- Simple mission statement.
- Supplier methods.
- Minimal tooling in final assembly.
- Minimal use of computers in production; just enough to plan.
- Tools at point of use.
- Workers in modules communicate directly with suppliers.
- Workers participate in product development, a great motivator.
- Workers self inspect; virtually no full time inspectors

Barriers for Aerospace

Military aircraft production is quite different than the agricultural products business. Some of Deere's approaches may not be transferable to aerospace. Some of the relevant differences are:

- Deere's production rates are roughly a factor of a hundred greater than those typical of military aircraft.
- The Federal Government imposes substantial control over the manufacture of aircraft in the form of specifications, regulations and accountability, elements that are absent at Deere.
- Although much of the aerospace industry works to dimensional tolerances comparable to those of the agricultural equipment industry, e.g., typically 0.030 for sheet metal, some of our production tolerances and critical manufacturing processes are more stringent than those found at Deere.
- Engineering changes are frequent in the aircraft industry and minimal in commercial production.
- Safety and other more stringent requirements make aircraft quality systems qualitatively different than those required for agricultural equipment.

Summary

Henry Ford's mass production revolutionized manufacturing. But it separated the doer (the worker) from the process fixer (the engineer). With that transformation, manufacturing process efficiencies were doomed to continually deteriorate as exogenous changes could not be readily accommodated and the worker did not have the power to make obvious improvements or to solve production problems.

Deere, like Toyota and many others, has brought the process doer and fixer back again together in the same individual, the worker. As a consequence, Deere's workers are able to continually improve manufacturing processes. In effect, processes become self-repairing and continually gain efficiency despite changes in their environments and requirements.

Most of the policies the team saw at Deere have the effect of equipping and empowering process teams, putting the worker back in charge of his process and rewarding him for improving it.

These are fundamental principles from the application of which the aircraft industry and its principal customer, the Federal Government, could benefit.

—o—

Annex 1

Roster of the Ad Hoc Lean Aircraft Initiative Team Visiting John Deere Harvester Works June 7, 1994

John Cantrell
Chief, Industrial Base Analysis Division
Manufacturing Technology Directorate
Wright Laboratory
Wright-Patterson AFB, OH

Mike Chapman
Electronics Fabrication & Assembly Development Manager
Boeing Defense & Space Group
Seattle, WA

Mark DiFilippo
Director Manufacturing Systems
Grumman Aircraft Systems
Bethpage, NY

John Fenter
Chief, Industrial Base Pilots
Manufacturing Technology Directorate
Wright Laboratory
Wright-Patterson AFB, OH

Phil Fletcher
Assistant to the Vice President Operations
Beech Aircraft Company
Wichita, KS

Tom Green
Product Development, Military Programs
Vought Aircraft Company
Dallas, TX

John Henderson
Manufacturing Administration
Boeing Defense & Space Group
Seattle, WA

Dr. Jim Ling
Research Associate
Center for Technology, Policy and Industrial Development
MIT
Cambridge, MA

Don Meadows
Director Lean Enterprise Strategic Planning
Lockheed Aeronautical Systems
Marietta, GA

Mr. Andrew Parris
Research Associate
Center for Technology, Policy and Industrial Development
MIT
Cambridge, MA

Paul Schumacher
Director of Manufacturing
Lockheed Advanced Development Company
Palmdale, CA

Steve Schwedt
Group Manager Engineering
McDonnell Douglas–East
St. Louis, MO

Fred Stahl
Director Production Transition
McDonnell Douglas–East
St. Louis, MO

Jim Struss
Director Quality & Productivity
Rockwell North American Aircraft
Rockwell International Corporation
Tulsa, OK

Mario Vitale
Manager Producibility Engineering & Materials Processes
McDonnell Douglas–East
St. Louis, MO

Phil Wilcox
Manager Scheduling
Aircraft Division
Northrop Corporation
Hawthorne, CA

Steve Young
JPATS Manufacturing
Beech Aircraft Company
Wichita, KS

Annex 2

Visit to John Deere Harvester Works
Topics Assigned to Individuals for Reporting

1. Key principles
2. Product Definition Process Changes
3. Cultural Changes, Union Issues, Job Security
4. Modules, Factory-within-a-factory
5. Fabrication
6. Assembly
7. Quality, Inspection
8. Supplier Management, Warranty Issues
9. Organizations of Teams and Overhead People
10. Training and Development
11. Worker Incentives, Quality, Process Improvement
12. Inventory
13. Management Oversight and Measures of Performance
14. Lot Size, Set-up Times, WIP
15. Cycle Times, Model Runs
16. Production planning, Management, Control
17. Activity-based Accounting, How Applied

Annex 3

Form Used for Data Collection at
John Deere by Ad Hoc LAI Team

Participant_____

Comments for Integration Into Ad Hoc Report

Please respond to the following questions. I will incorporate our comments into a report for use by you, the other participants and the LAI. Please don't be constrained by the space on this sheet.

1. Please give the following subject special attention during our visit to Deere.

_____

2. On that subject, please provide a description of Deere's approach.

_____

_____

_____

_____

_____

3. Based on your personal experience, which aspects of the subject Deere approach might be adaptable to the manufacture of aircraft. How

_____

_____

_____

(question 3 continued)

_____

_____

4. Based on what you saw and heard, can other parts of Deere's program of manufacturing change be usefully applied in the aerospace industry?

_____

_____

_____

_____

Please hold all Deere information in confidence.
Fax replies to Fred Stahl, (314) 232-0120