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Caterpillar 994 Wheel Loader Breaks Traditions, Forecasts Future

To call the Caterpillar 994 Wheel Loader a "new and improved" model would be gross understatement. Unveiled at a public dedication ceremony August 24 at Caterpillar's Decatur, IL, plant, the Model 994 represents a new approach to product design and development.

The time frame for this project, from first drawing of the center lines to producing a working machine, was 33 months. Usual product development time is six to seven years. Cutting development time to less than half the norm is even more impressive when the size of the machine is considered.

The size of open pit mining equipment is extraordinary. The Model 994 weighs 381,000 lbs., roughly equivalent to 100 Cadillacs. Its tires, weighing over 10,000 lbs. each, are over 12 ft. in diameter with enough rubber in them to make 80,000 golf balls. The bucket scoops up 70,000 lbs. of earth in one bite.

Despite its size, the Wheel Loader is very maneuverable, and the operator has good visibility for stripping overburden and loading trucks.

The 994 is Caterpillar's largest wheel loader and, when used in conjunction with the company's larger trucks, will provide an increased level of productivity while reducing the number of machines and machine operators required for the job.

The size of the product creates logistical problems in manufacture and assembly as well. Because some components weigh as much as 35 to 40,000 lbs., the design process must take into account adequate lifting and tie down procedures. Field assembly requires hoists and cranes, not lift trucks.

Besides the tightened time frame, the 994 utilizes a communications philosophy much different from previous Caterpillar introductions. Three years ago, the company announced to its dealers the Model 994 would be out in mid-1990. Long before the design was completed, preliminary spec sheets were distributed and dealer input solicited. Under the old system, no information was given until the new machines were already in the field.

Teamwork was essential to meeting those tight deadlines. Union personnel demonstrated a high degree of hard work and dedication to this project. "I've never seen anything like the way this team worked together," says Ken Wolfgram, Caterpillar Senior Project Engineer, Mining Vehicle Center.

Design procedures were stream-

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These two men are dwarfed by the 994's lift arm and bucket linkage.

Caterpillar secured a patent on RFA's concept for a sliding ladder design.

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RFA Resource

Mike McGraw, Engineer

Current Project: Checker on various projects for Caterpillar.

Areas of Expertise: Power trains, knowledge of gear design, shaft and bearing design.

Training/Work History: University of Minnesota, 1961, Mechanical Engineering.

Prior to and immediately after graduation, Mike worked with Falk Corp., a large gear manufacturer in Milwaukee. In Mike's area, special applications, the company developed gearing arrangements, modifying its standard line of gear boxes and open gearing, to drive equipment like ball mills for crushing iron ore and cement kilns.

Returning to Minneapolis in 1963, Mike joined Minneapolis Moline Co., which later became a division of White Farm Equipment. During his nine years there, Mike worked mainly in the drive train portion of Moline's line of tractors, both in designing new models and in solving problems on existing models.

When White relocated, Mike moved on, in 1972, to Capitol Gear Co. in St. Paul. The company produces gear boxes for the marine industry, generally small fishing vessels and large pleasure craft. Again, Mike designed gears for specific applications and worked with shafts, bearings and clutches.

Although Mike's job description at Capitol Gear and other companies may have been design engineer, his job function has never stopped at design. At each of his positions, his responsibilities covered design, overseeing test runs, solving production problems and ensuring the equipment functioned as intended.

After a downturn in Capitol's business, Mike joined Horton Industries, Minneapolis, in 1977. Horton Industries is an O.E.M. supplier of clutches used on large, diesel over-the-road trucks. Mike's area dealt with the application of clutches to engage and disengage the engine fans to increase overall engine efficiency.

Again working in power trains, this time on cranes, Mike joined American Hoist & Derrick (later called Amhoist, then Amdura) in 1981. The cranes produced in the company's Marine & Energy Division were mounted on barges which required different support systems and the ability to take heavier loads than land-based cranes. These marine cranes were used to build off-shore oil well sites, particularly those in the North Sea.

Five years later, as Amhoist prepared to spin off its Marine Division, Mike was laid off and took a position with Aqua City Irrigation, Minneapolis. During this period when he was designing and selling commercial irrigation systems, RFA learned he was available.

Jim Rother, RFA's chief engineer, had known Mike and his expertise for 20 years, beginning with their working together at the old Minneapolis Moline Co. Although Jim offered a better salary and more challenging work, Mike kept his commitment to Aqua City, staying with the company till the end of its season before joining RFA in November, 1987.

RFA Projects: Mike McGraw brings nearly 30 years experience in power trains to his RFA work. Power trains is a relatively narrow niche, attracting people who are suited to very precise work and who are willing to specialize.

The demand for that expertise at any one company fluctuates, but when the job calls for a power trains specialist, there's really no substitute. The field may be narrow, but the depth of information required is not, e.g., knowledge of gears, shafts, bearings, seals, housings, lubrication and manufacturing processes. And, since these components respond differently to different environments and under different loads and stresses, the field is not one an engineer becomes productive in overnight.

RFA is utilizing Mike's attention to detail and long-time experience on both checking and preliminary analysis projects. His first year, he acted as checker in the final phases of a tractor transmission for Ford. He currently performs checking on projects for Caterpillar, checking computer generated drawings, doing stack up tolerances and doing some redesign of subassemblies.

On the Caterpillar 994 Wheel Loader featured in this issue, RFA provided stress analysis, gear sizing, drawings and tolerance stack for its two pump drives. Mike was the checker on both the analysis and the tolerance stack-up.

"To be a good checker, you have to be a good engineer or designer first," Jim Rother reminds us. "A checker has to have the background to understand how something functions before he can pass judgement on the drawings." But, as important, "Mike is easy to work with. He works to form a consensus and tries to get the most out of people."

Mike has worked on several preliminary analysis jobs, one of which was a stress analysis study for the gearing in a commercial lawn mower transmission.

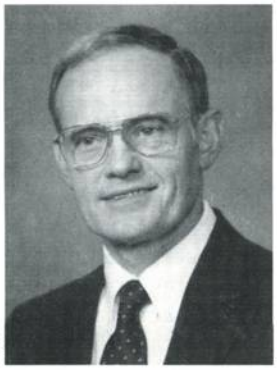
"Mike is a hard worker. His coming here has certainly benefitted RFA," Jim adds. "And he likes to give our customers the most bang for their buck."

CADAM Users: RFA now has PC-based MICROCADAM and workstation-based PROFESSIONAL CADAM.

Quirks

...Citing a projected shortage of 560,000 science and engineering professionals by the year 2010, the National Governor's Association recommends targeting women and minorities and implementing programs to encourage their entrance into science and engineering careers.

...Ford Motor Co. has struck a pact with OSHA to reduce ergonomic hazards in most of its plants. This could result in the redesign of workstations and tools and the increased use of



Ben Barnard
President

The Caterpillar 994 Wheel Loader project featured in this issue was a success by all accounts. It was a huge project requiring thousands of man-hours, adherence to tight schedules and impeccable coordination. And it all worked.

As in every successful project, the individuals the client assigned to work with us was critical. Ken Wolfgram in Decatur and Chuck Chappell at Aurora made it easier for us to respond and adapt to the client's needs. I don't know any other project in which we have been advised so clearly where it was going, what changes were taking place and the reasons for those changes. Ken focused on where he was going and never got bogged down in problem areas.

Now, RFA/Minnesota Engineering has been working with Caterpillar for 13 years. We know each other. We know how each of us works, and the working relationship runs reasonably smoothly.

And, yet, because of the magnitude of this project–60,000 man-hours and up to 40 RFA people at one time–the issue of confidentiality came up again. I suppose any client would have some qualms about farming out that large a portion of a project.

Often, clients and prospective clients are concerned that design details we prepare will somehow get into a competitor's hands. It would not be in our self-interest to let that happen. If we were to show client designs to a prospect, we would lose the respect of that prospect in the process anyhow.

And, contrary to popular thought, that scenario rarely occurs. In my 18 years at RFA, I have seen only one or two cases where a prospect came in on a "fishing expedition," attempting to get information on a client's methods or plans for development.

In reality, the concern about design details doesn't stack up. Few engineers would accept someone else's design detail just because it was someone else's idea. It's the NIH syndrome.

Usually there is good reason to reject another company's design detail. It may cost too much to produce. It may not fit in with the prospect's manufacturing capabilities or its existing components.

In design, the philosophy behind the design, how a part will be serviced or how it will be manufactured, are all so tightly tied together that even if we gave a prospect a whole truckload of drawings, there is very little that could be done with them.

If RFA used the same staff to design the same machine for two competing companies, the designs would be entirely different. Any design we do has to be compatible with that particular client's complete line of products for appearance and serviceability. It has to be compatible with that company's manufacturing processes and utilize components that are selected or even manufactured by the client.

Our drawings must look as though the client's own staff did them, both for ease of integration with the client's other work and to better enable the client to take ownership of the design at project completion. This principle is clear to the people who work with us but seems never to be clear to those who don't or to those who do not understand the realities of the design decision-making process.

A company's ultimate security has far more to do with its financial strength, its history, its manufacturing ability and its marketing ability, that is, having the right product at the right time. It is the company's whole culture that is the critical issue, not how it inserts a pin or adjusts the bearings.

There are certain areas which do require greater attention. Analytical procedures, test data, load criteria, all must of course be closely guarded. Other than these areas, however, the conditions of the design process are such that, in our experience, the concern for confidentiality is a moot point.

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lined. A smaller group of individuals comprised the design committee. Internal guidelines were developed which drastically condensed four volumes of design standards into a 150-page notebook. This information was provided to RFA/Minnesota Engineering early in the program.

Selecting RFA as a supplier was a natural choice for Caterpillar. Because of our longstanding working relationship, our people are familiar with Caterpillar procedures. We offer flexibility, adding on or taking off employees as needed.

The Model 994 project started in November, 1987, when Ken Wolfgram laid out the center lines. He soon was joined by four other engineers at Caterpillar's Aurora, IL plant.

The group brought its first concept work to RFA in February, 1988. Our Theresa Mahnke-Fisher, along with Chief Engineer Jim Rother, developed the front pump drive. Later, they worked on a rear pump drive from a design provided by the East Peoria, IL facility.

Caterpillar breaks up the design and manufacture of its products into what it calls "design controls." Besides overall responsibility for the project, Ken Wolfgram also was the design control leader for vehicle development, that is, the chassis, sheet metal, frame and related structures portion of the machine. And,

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mechanical lifting devices. Chrysler committed to a similar program last year.

...For those perfectionists who don't understand why the color of a knit collar doesn't exactly match the color of the rest of a shirt, a new computerized system to control the dye process is expected to lead to more consistent dye lots of yarns and fabrics. The announcement was made by a professor of mechanical and aerospace engineering at North Carolina State.

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this is the area in which RFA was most involved.

After the pump drives, RFA incorporated a basic radiator into the vehicle, designing the mounting, sheet metal, grill work and access points. Much of our work follows similar lines. The Aurora engineering group supplied rough concepts. RFA "fleshed" them out, made modifications and incorporated components into the vehicle. We also modified the cab and detailed the front linkage.

One of the major packages RFA worked on was the drawbar and bumper arrangement. This is a module that sits underneath the rear of the machine and which incorporates three fuel tanks, the access ladders, hand rails and some electrical controls for turning on lights and turning off the engine in case of emergency. (The operator's cab sits 21 ft. off the ground.)

A sliding ladder concept developed by RFA's Larry Hoben, layout drafter, has been patented by Caterpillar. The components are not new, but the packaging is. The access ladder and hand rail are integrated into one design. The ladder slides on the hand rail so that the vehicle operator can pull it up and out of the way during machine operation.

Hydraulic and electrical detailing came later in the program. Here, RFA's involvement, especially in the electrical design, was extensive. Of the 60,000 man-hours and approximately 1,000 detail drawings RFA supplied for this project, the bulk of the work was in systems integration.

The sheer size of the machine, the distance wires had to run, was one factor. Another is the new, advanced design of the Model 994. More functions are controlled from remote areas of the machine. This model has more electronic controllers than previous wheel loaders, and it is designed so that future electronic controls can be added without disrupting other systems.

"Their (RFA's) role in this project was tremendous."

The modular build of the machine required increasing the number of wire harnesses from the usual 10 or 12 to 30. One harness configuration may house up to 104 wires which are then routed to other controllers, to temperature sensors, to pressure sensors, the pumps, the engine, and so on. Wires and the structures to support the electrical system were detailed for every square foot of this 381,000 lb. piece of equipment.

RFA Designer Ralph Hyde, working under Project Engineer Dave Roesler, had primary responsibility for concepting and coordinating the electrical layout. He also followed through on the translation of our drawings into the Aurora plant's computerized detail drawings.

Coordinating a project of this size in a relatively short period, required Ken Wolfgram to put in many 70-80 hour workweeks and a substantial amount of time at RFA's facility. Coming in for two days at a time, Ken would sit down with Dave Roesler and review the work of from a half dozen to up to 40 RFA personnel involved in the project at any one stage. Ken figures he spent over one hundred days in our office.

"The hours RFA worked, saved us, as a corporation, from having to hire additional people who may or may not have been kept on after the program was completed," Ken explains. And "the primary thrust of the program was to get it done in a hurry. You have a hard time getting employees who are knowledgeable about the way Caterpillar does things if you go outside to hire. RFA is very familiar with the way we operate. Their role in this project was tremendous."

Also new to this Model 994 Wheel Loader is the kind of new product introduction Caterpillar launched. The public dedication ceremony at Decatur was a grand affair with company executives, local and trade press, other dignitaries and RFA attending. That first 994 Wheel Loader has since been shipped to a copper mine near Tucson, AZ.

Justifiably proud of this program, Caterpillar may model future projects along similar lines. The secret of its success? Ken Wolfgram says, "a lot of dedication, a lot of teamwork and ignoring some of the sacred cows that crop up in corporations."

RFA/Minnesota Engineering Co. has been a continuous supplier of engineering services to Caterpillar since 1977.

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