CMU-led automation program puts robots in the field

BY BRETT DAVIS

When researchers at Carnegie Mellon University wanted to evaluate the usefulness of their ground robot for orchard growers, they did something radical — they put it in the hands of actual orchard growers.

The team leaders of the Comprehensive Automation for Specialty Crops (CASC) program have developed a machine, based on a commercial Toro platform, that can autonomously trundle down orchard rows, allowing human workers atop it to prune, thin fruit, train and tie trees, or harvest.

"For the first time in my career, we developed robots … and we gave them to Penn State and Washington State, to the [agriculture] extension people," says Marcel Bergerman, the CASC project manager and a systems scientist with Carnegie Mellon's Field Robotics Center. "Not to engineers, we gave them to the extension people, and they take these machines to actual orchards, commercial orchards with growers, and they go in and do the experiments themselves."

Previously, orchard workers would take a ladder, climb it to perform a task, climb back down and move the ladder.

"Now this is driving slowly down the row, and instead of literally going up the ladder, down the ladder, and moving the ladder, over and over again. There are some statistics, I don't know the exact numbers, but about 30 percent of accidents in orchards can be somehow related back to ladders," says Bergerman.

To avoid that, CASC developed an automated version of Toro's E-Workman platform, named the Autonomous Prime Mover. They delivered APM systems to agriculture extension programs and growers last year, keeping one in-house for system modifications and testing. The APM has a scissor lift on top of it that can carry two workers, who can control the vehicle if they want but who no longer have to climb up and down ladders.

The APM vehicle in "bin dog" mode. Photo courtesy CASC.

"It's an interesting case. It's autonomous but manned," says Sanjiv Singh, the project director and a research professor at the Robotics Institute.

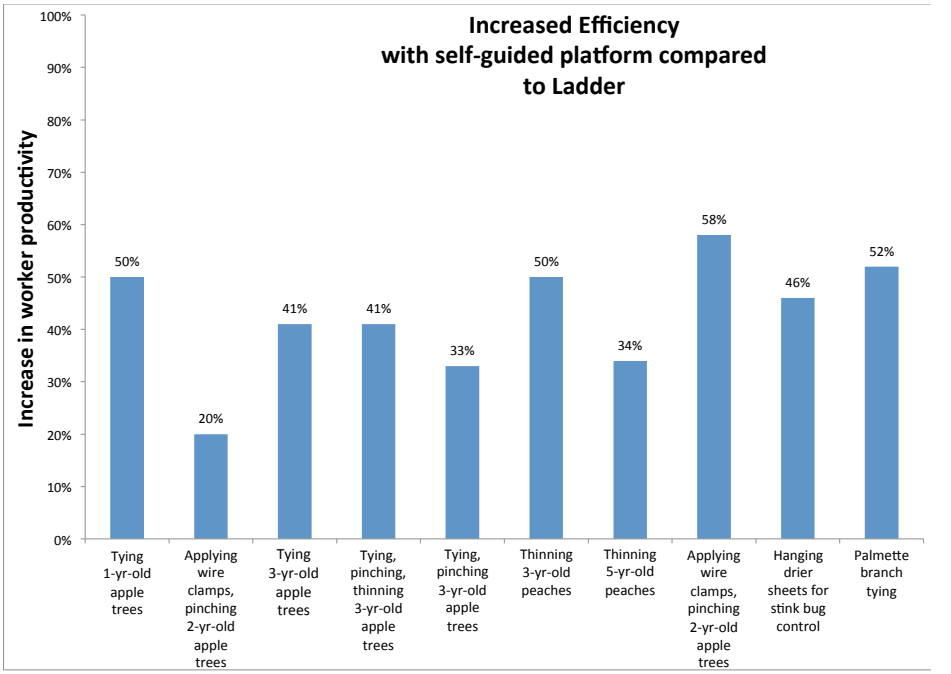
CASC has developed two generations of the machines, which have grown a little bit simpler over time. The first version had an iPad interface, but "iPads aren't meant for readability in sunshine" and they can heat up, even in the winter, Singh says.

"We've gone back and done something a little bit lower tech but more sturdy, and it will work in any lighting condition," he says. The interface now sports an E-ink panel, like a Kindle e-book reader, and has more discrete buttons, a slider bar for speed control and a foot pedal.

"You put it at the beginning of the row, flip the switch, and … you press the foot pedal and the vehicle starts creeping in the row," Singh says. "When it gets to the end of the row, it detects the open space with a laser and stops automatically. The workers atop the scissors lift use a joystick to drive it to the next row. … It's an autonomous vehicle that does one thing only."

That one-trick pony has a good trick, however. CASC loaned the vehicles to the agriculture extension programs at the partner universities, which in turn lent them to orchards. In one case, the extension program also set up a John Henry-style competition between the APM and a man on a ladder.

The video, which was shown at AUVSI's Unmanned Systems Program Review 2012, showed that the automated platform is capable of making much better time.



The results of a timed trial between the APM and ladder-using workers.

CASC

The overarching philosophy of the CASC program is to go "from information management to mobility to manipulation," Bergerman says.

Information is data about crop health and yield, using such things as soil and moisture sensors, automated calipers and counters, and fruit counting and sizing systems, to allow farmers to make better management decisions. Mobility means a vehicle, such as the APM, that allows autonomous mowing and spraying. Manipulation means higher level functions such as pruning, thinning and harvesting.

"Let's jump forward into the future — 10, 20, 30 years. A robot will go out and do the pruning and the thinning and the harvesting for you," Bergerman says. "That's not our focus right now. The focus is how do you augment human workers to make them more productive, more efficient and more safe."

CASC is funded at $6 million by the U.S. Department of Agriculture Specialty Crop Research Initiative, established by the 2008 farm bill, with matching funds from industry and university partners. Those partners, in addition to Penn State and Washington State, include Oregon State, Purdue, the USDA Agricultural Research Service Appalachian Fruit Research Station, Vision

CASC leaders Sanjiv Singh and Marcel Bergerman at the Mid-Atlantic Fruit and Vegetable Convention. AUVSI photo.

Two workers thin green fruit at Allan Bros. Orchards in Prosser, Wash. In timed trials in Pennsylvania comparing workers on the vehicle with workers on ladders, CASC obtained up to a 58 percent efficiency increase. Photo courtesy CASC.

Robotics, Toro, DBR Conveyor Concepts, Spensa Technologies and Trimble.

Its initiatives include developing an automated bug trap that can trap and count specific types of insects, an automated tree caliper and counter, a harvest augmentation system, and a scout vehicle that assesses crop load.

The program has included the work of 69 students in its three-year life, including summer students and those who have worked with it for its whole existence.

"One of the reasons the program was created, besides creating new technology, is to educate a new generation of ag engineers," says Bergerman. "That's been missing in the U.S. for a long time now."

End users

Singh and Bergerman attend events such as the recent Mid-Atlantic Fruit and Vegetable Convention in Hershey, Pa., where they spoke with *Mission Critical*. They use such events to demonstrate their technology and discuss how farmers might use it and how they feel about it.

In the first year, Singh says, the planned equipment tended to be expensive and the reaction was "pretty muted." Now farmers and growers "have started to get a little more excited about it … because they can actually see connection to their work," Singh says.

Price is a huge consideration in the agriculture market, he says.

"If you suggest a $5,000 user interface for a military system, it's not a big deal. No one even asks about that. You couldn't have a $5,000 control interface for an ag robot; it just would not compute," he says.

That also means that the machines can't be made as smart as the orchard growers might like. Singh says some growers have said that the machines couldn't work for them because they're not smart enough to negotiate the ends of tree rows, where the ground may slope up or down. Growers tend to use as much land as they can, which leads to irregularity at the ends of the rows.

"Somebody asked me about that today when I was giving my talk: 'I don't believe your machines are going to be able to deal with the ends of rows.' I said you don't want us to deal with that, because you wouldn't be able to justify the extra cost associated with that. You'd be better off making your rows slightly shorter and giving the vehicle a little bit more room to turn around in the flat area."

In other words, "If you're going to automate orchards, you're going to have to build them to suit," he says. "This is kind of the educational process. … We build these machines to spur people to ask questions."

Brett Davis is editor of Mission Critical.

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