# Predicting technological trends in citrus field equipment

By John K. Schueller

Drone collecting images of fruit on trees.

These are thrilling times in the mobile equipment world. Drones, autonomous cars, wireless connectivity and more are exciting everyone. Some of the long-predicted advances in mobile equipment may finally be set to occur.

These advances will eventually be reflected in citrus groves. But how will the advances be adapted to the needs of the citrus industry and when will that occur? That is difficult to predict.

Of course, currently the citrus industry is significantly concentrating on citrus greening. This concentration not only applies to the dedication of scarce financial resources in a time of reduced production, but also the intellectual focus on research and development to counteract this dreaded disease.

Another factor limiting technological development for the citrus industry is its size. While the citrus industry is important in Florida and California, it is small compared to other mobile equipment industries, such as automotive, and other agricultural commodity areas, such as corn and soybeans, in terms of how much equipment can be sold. There is insufficient equipment market volumes to encourage rapid technological development and adoption. So equipment development and adoption is predicted to be slow unless the technologies can be adopted or adapted from other industries. Nevertheless, it will move forward.

## DROP-IN VS. SYSTEM TECHNOLOGIES

A big factor in the adoption of new agricultural technologies is often whether the new technology is "drop-in" or "system." The classic, traditional "drop-in" agricultural technology is hybrid seed. No changes to the system were required, and adoption was very fast. The classic "system" technology is the tractor. Besides the machines themselves, tractors required fuel, maintenance, new implements, etc.

Therefore, the adoption of tractors was slower.

A similar situation can be seen in contemporary corn-soybean agriculture. Automated steering was quickly adopted by larger field crop farmers because it was a simple "drop-in" technology for tractors. Precision agriculture, a "system" technology involving sensing, management and control of multiple equipment and operations, is being adopted much more slowly by the same farmers.

A "drop-in" technology for citrus is a sprayer which senses tree size and turns on and off the appropriate nozzles. This is easily adopted, and has been by many growers. A "systems" technology which combines tree characteristics (size, age, nutrient levels, disease infestation, etc.), previous yield and very localized soil characteristics to determine fertilizer mix and rate for individual trees is obviously more complicated. Such systems will likely be adopted eventually, but it may take some time.

**Fruit automatically marked and counted by flying a drone in Central Florida.**

## DATA AND SENSORS

The biggest general technological advance which will affect citrus mobile equipment is the continuing progress in computing. We are reaching the point at which computers are able to do almost any data processing we want, and data storage is essentially free. This allows us to do precision agriculture in the citrus grove. Detailed data can be stored on every tree or every small length of hedgerow. These single trees or hedgerow segments can automatically be managed individually to maximize productivity and profitability.

The availability of accurate, cheap, automated data is the key requirement. In fact, sensors may be the most important component of acquiring information. One very important area of advancement for citrus is in image acquisition and processing. As we know from our cell phones, this technology has greatly advanced. It is very likely that soon images will be taken whenever mobile equipment moves through groves. In addition, robotic scouting devices, both ground-based and drone, will collect data when needed. The fruit on the tree, the dropped fruit and the canopy itself will be studied. LIDAR (light detection and ranging) and 3-D cameras will give the images depth data, and GPS will establish geographic location. This will allow the generation of accurate 3-D models of the fruit and citrus canopy.

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Besides the above machine-vision sensing, spectroscopic data will also be gathered. Based upon the reflections of visible and invisible light bands, the health of the tree and the fruit will be determined. This will determine nutrient deficiencies to prompt corrective, spatially variable fertilizer applications. Perhaps more importantly, it will allow early detection of diseases.

## ROBOTICS IN THE GROVE

Although robot technologies are widely used in tightly controlled manufacturing facilities, they have not received widespread adoption in production agriculture. The physical, chemical and biological complexity and variability of outdoor agriculture is very difficult to automate. But, I think it will not be long until robotic mobile equipment will be present in citrus groves. As mentioned above, small ground-based vehicles and drones will perform scouting operations.

It is likely that robotic sprayers will also soon be adopted. That adoption will be spurred by the need to ensure that operators are removed far from the pesticide spray cloud. Of course, the spray cloud will be continuously and automatically changed so that there is deposition over the full tree and no application where canopy is not present. This will involve real-time monitoring of both the tree canopy and the spray cloud. Whether sensors on the applicator are sufficient, or a small drone is needed to monitor, is still not clear.

Other grove-tending operations which do not need to interact with the trees will also be among the first to be made robotic. For example, mowing can be made robotic. Making the moving of harvested fruit to the edge of the grove robotic is more difficult as the fruit needs to be transferred on both ends, but those transfers occur in relatively clear and deterministic non-biological situations.

Since harvesting represents the largest labor cost of citrus production, robotic harvesting has long been a priority goal. It is hard to predict when harvesting will be robotic. My guess is that it will be a very long time for juice oranges and grapefruit

**Unmanned autonomous sprayer operating in southwestern Florida.**

to be individually picked with robotic arms. But the current mass-harvesting, canopy-shaking machines will return to action once we learn to live with HLB. The machines will then be more intelligent and have sensors and automatic systems to control the shaking to maximize removal and catching while minimizing tree and fruit damage.

Fresh market citrus may eventually be individually robotically picked. I think robotic engineers will develop low-cost, multiple-arm machines that sacrifice the unneeded accuracy that contemporary robots have to get sufficiently short picking-cycle times. However, very significant advances will have to be made to make robotic-arm harvesting economical for juice citrus.

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Groves and trees will have to be designed and grown to facilitate productive and efficient use of automation. Citrus will join other fruit crops, such as apples, in being grown in narrow hedgerows with ruthless hedging and topping to produce near-planar fruit locations. In order to maximize production, the distances between the rows will be decreased. This means that equipment, such as sprayers, will be designed and selected to accommodate narrow middles.

Contemporary agricultural equipment is becoming very networked. Tractors, for example, now utilize the ISOBUS to communicate between their various components and with some implements. It seems very apparent that all the mobile equipment will soon communicate with each other and with the centralized farm management.

## WHEN WILL IT HAPPEN?

It is difficult to predict technological developments and their adoption rates. But if I must give a prediction, it seems to me that the following technologies might be developed and/or adopted in the near term in citrus groves:

- More complete adoption of pesticide and fertilizer applicators which respond to the presence or absence of canopy
- Sensors that can be mounted on vehicles or drones to GPS-map yields and tree health
- Autonomous robotic sprayers and mowers

In the medium term, the following might be developed and begin adoption:

- Sophisticated and centrally controlled optimization of spatially variable water and fertilizer application to maximize production and minimize environmental impacts
- Adaptive canopy-shaking, mass-citrus harvesters
- Autonomous vehicles to transport harvested fruit out of the grove

Long-term predictions of technology development and adoption are too unreliable. But I'm optimistic that the U.S. citrus industry will remain strong despite the great challenges, such as HLB. Technological advances will help meet those challenges.

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