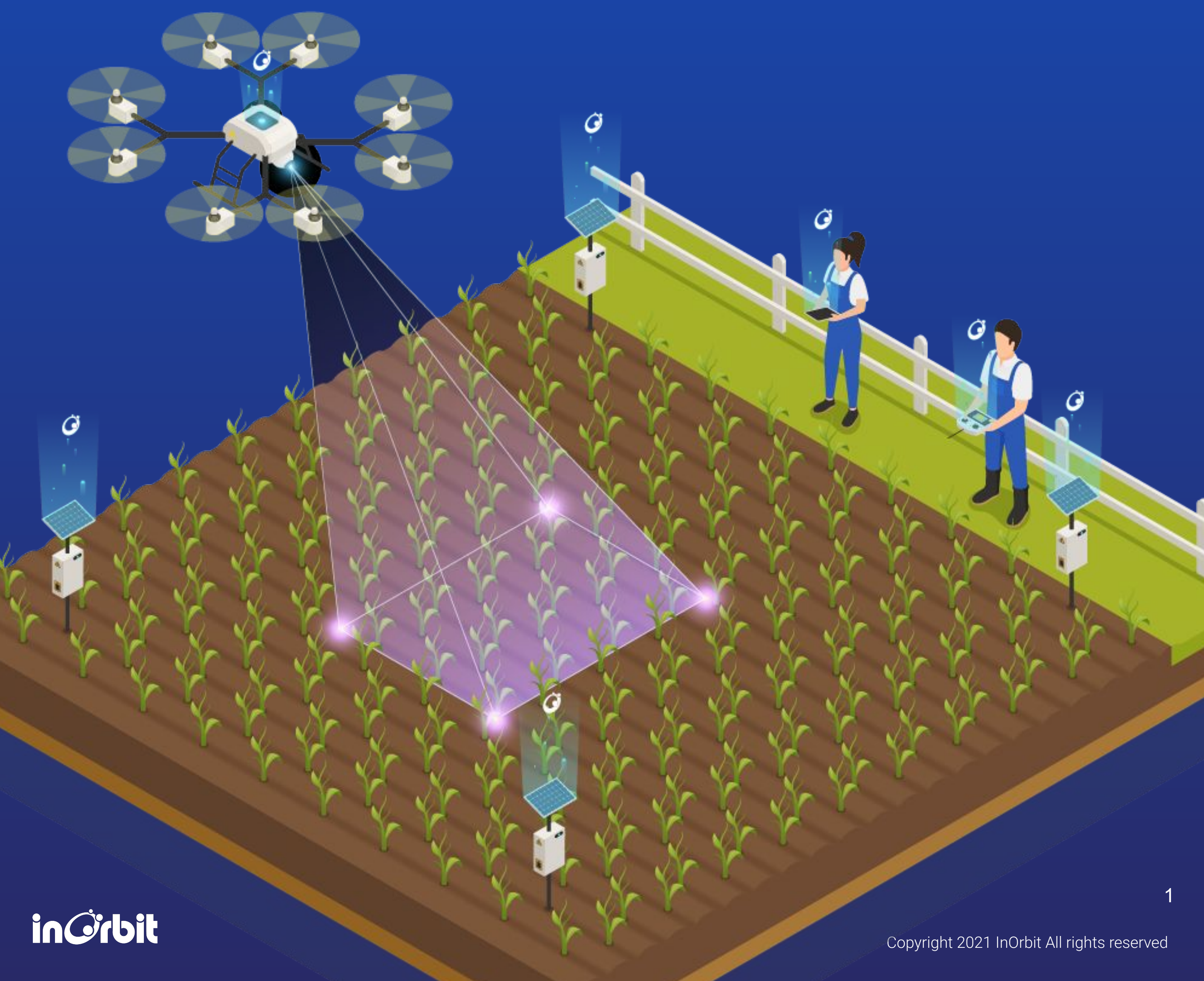
Automated Agriculture

Why robots and humans working on farms will require smarter orchestration.



inOrbit


Robotics is set to impact the world of agriculture. Photo: Deere & Co.

As the planet's population continues to grow exponentially, the ability for humans to harvest enough food while also acting sustainably to reduce harmful climate change is a major challenge for the next 30 years. By some estimates, the world will need to increase current production by 25% to 70% to feed a predicted population of 9.1 billion people.

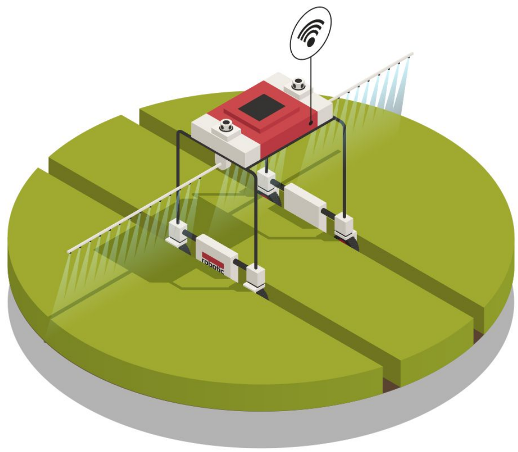
Automation, artificial intelligence and robotics are seen as major players in helping humans achieve this lofty goal. We are now just planting the seeds of technology that will achieve a world of automated agriculture, not only to increase the yield of crops, but also to become more sustainable to protect the environment, as well as reduce reliance on a manual labor supply that is woefully inadequate even now.

Because many tasks within farming are manual tasks – especially picking certain crops – farms have often relied on a migrant workforce to perform these processes. However, high turnover and constant labor shortages (whether from political or seasonal reasons) make this challenging for farming operations. Similar to human workers in the e-commerce warehousing space, manual farming tasks are often dirty, dull and dangerous, which are often mentioned as types that robots can perform.

Like many other industries, companies within the farming and agricultural sector are exploring many different approaches to automation. Diverse robotic applications cover the landscape, ranging from automated heavy equipment like tractors and harvesters, to robotic arm pickers and autonomous mobile robots that can move and store harvested crops in orchards.

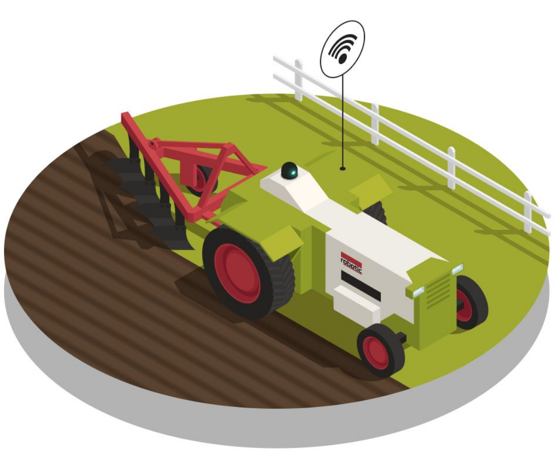
Inexpensive aerial drones can fly over farmland to record data on crop yields, pointing out which areas might need more or less water. Precision farming machines utilize artificial intelligence to directly target weeds for pesticides, rather than blanketing a field with harmful chemicals. In the indoor farming space, milking robots have been available for dairy operations for several years, and we are seeing vertical farming robotics that can harvest greenhouse-grown crops.

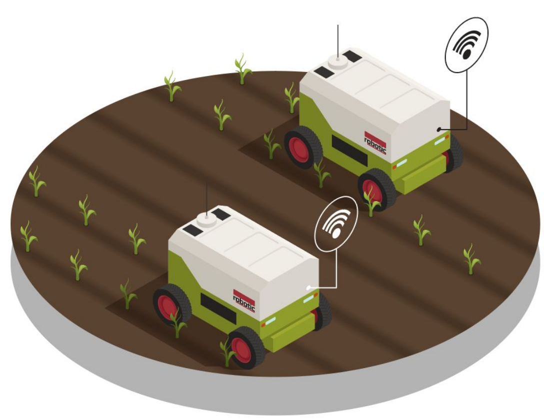
In each of these cases, we are seeing early projects that look to automate a single task within agriculture, such as weeding, harvesting, planting, or spraying. Farming operations will likely pick one of these areas to automate before moving to additional applications or robots, rather than “betting the farm” by trying to automate everything all at once. However, success in one area of automation will likely lead to additional projects, similar to what is happening within the warehouse and distribution center space, where multi-robot projects are beginning to emerge.



While companies can learn much from earlier automation efforts in the supply chain and logistics space, there are several unique challenges for agriculture robots not present in the warehouse. First, many robots will be deployed in outdoor environments, having to deal with much harsher weather conditions and environments than an indoor warehouse. Indoor farming and greenhouse growing can reduce the impact of the weather, but come with additional challenges related to humidity that could affect physical equipment. Limited network connectivity in outdoor environments could affect coordination of robot tasks or the speedy transfer of data from these systems. Obstacles such as other workers, trees and even farm animals require the latest advances in machine vision.

To meet these challenges and to scale automation to increase production, farming groups will need a coordinated effort between the latest robotics hardware, advanced software to orchestrate robot operations (RobOps), and fast communications to the cloud via advanced Wi-Fi, 5G (or greater), or possibly even satellite-based technologies like Elon Musk’s Starlink.





Types of robots in farming

Just like there are different types of farms in the world, technology aiming to address automation of farming is just as diverse. There is not just one kind of robot that can operate on a farm – many depend on automating a specific task, such as harvesting, seeding, spraying pesticides, or weeding. Here are a few examples of equipment being automated:

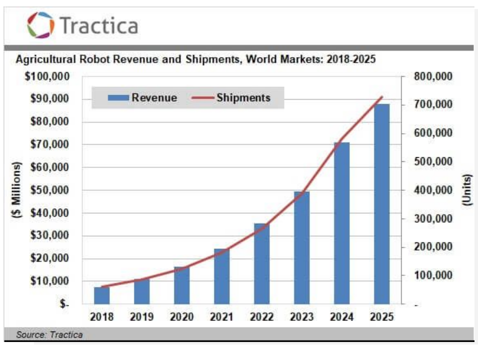
- **Heavy equipment:** Large tractors and harvesting equipment that require a human driver are being automated, similar to the way driverless cars are being developed. John Deere is a leader in this space, having acquired two companies developing automated tractors – **Blue River Technology** in 2017 and more recently, **Bear Flag Robotics**. The company has also developed several other technologies, including improving precise location technology that vastly improves GPS. Companies like **Monarch Tractor** and **AgJunction** are developing autonomous tractors, and **Horsch** and **Trimble** have announced a collaboration to develop autonomous systems.
- **Mobile robots:** **C-Link Systems** develops unmanned ground vehicles that can help clean up horse farms and provide landscaping and seed distribution assistance. **Clearpath Robotics**, which also makes robots for indoor warehouses, has several different rugged unmanned ground vehicles for outdoor use, including materials handling.
- **Drones:** Autonomous aerial drones are being deployed in many different scenarios to help farmers analyze data from crops, or to perform different operations. For example, **Precision AI** uses drones and computer vision to enable precision application of herbicides to individual weeds in crop farming. **XAG Drones** in Australia are being used to apply precision spraying to help curb the spread of the African Lovegrass exotic weed. **Aerobotics** uses drones to gather data on crops, including identifying underperforming areas caused by pests, diseases, or irrigation issues.
- **Weeding:** Speaking of weeds, **Carbon Robotics** is developing an autonomous weeder that combines robotics, AI and laser technology to drive through crop fields to identify, target and eliminate weeds. **Farmwise** is developing a robot that could kill weeds without using chemicals. France's **Naio Technologies** makes weeding robots designed for vegetable farms and vineyards, in addition to a multi-function mobile robot that can help farmers seed, harrow and perform other field tasks.

Bear Flag Robotics

HORSCH

XAG Drones

- **Greenhouse farming:** [IronOx](#) develops robots for its hydroponic growing system, which uses 90% less water than traditional farming, while growing 30 times the amount of crops per acre of land. [Tortuga AgTech](#) uses robots for picking strawberries and other crops in greenhouses. [AppHarvest](#), which recently acquired Root AI, utilizes robots to help pick tomato plants.
- **Vertical farming:** [Intelligent Growth Solutions](#) is developing growth towers for indoor farming that manages light, temperature, humidity, water, and nutrients. [CubicFarm Systems](#) is developing automated growing systems to support fresh produce and livestock feed markets.



"Global shipments of robots designed for agricultural use are set to rise to $87.9 billion by 2025"
source: Tractica

- **Harvesting:** Many companies are attacking the task of picking crops, such as fruit-picking firms **FF Robotics**, **Ripe Robotics**, and **Tevel**, which utilizes a tethered drone to pick fruit with a robotic arm. **Future Acres** is applying the autonomous mobile robot model to help farmers gather hand-picked crops more efficiently, by following pickers autonomously. New Zealand's **Robotics Plus** develops an automated system that helps pack apples once they're picked.
- **Milking robots:** Dairy farms have long utilized milking robots to help automate the milking process. Companies like **DeLaval**, **Fullwood Packo**, and **Lely** offer systems that automate milking and feeding of cows.
- **Manure collection:** Definitely a "dirty task" best handled by robots, manure collection has been addressed by some robot makers. Lely makes the Discovery Collector, a cleaning robot for manure collection/cleaning. The SRone and SRone+ from **GEA** are scraping robots that help clean slatted floors. Other manure robots can be discovered here.

American Robotics’ Scout drone

This is but a small sampling of the companies looking to develop automated systems. Additional areas seeing automation include soil management, irrigation management, pruning, weather tracking, and even inventory management systems. Like robots in other fields, if a task is “dirty, dull, or dangerous” for a human, it can likely be handled by a robot – at least, that’s what several of these startups are aiming for.

Challenges of automated agriculture

Robotics have primarily succeeded in locations where the environment can be controlled to reduce interference, such as an automotive factory where industrial robot arms can be caged off from humans and other obstacles. In warehouses, advances in autonomy software, vision cameras and lidar have allowed robots to move around such impediments as well.

For robots working in outdoor fields, however, challenges can come from Mother Nature in addition to human and animal interference. Rain, wind, dust and heat can all play havoc with a robot’s sensors and systems, so robot makers need to make sure any equipment is protected through environmental safeguards. Even a bright sunny day can cause reflections that could interfere with a robot’s vision sensors.

Additionally, many of these robotic systems will likely need to be recharged or refueled during their operations. While there are advances in refilling and recharging stations (for electric vehicles), it's more likely that humans will need to stay in the loop to perform maintenance tasks. For robots that are conducting precision agriculture applications, they will also need to remember where they were when they stopped or went back for refueling, so they can continue the job once they have power or fuel again.

Developments in automated farming solutions have largely ignored scale and to an extent cost. Farms of varying size and capacities require different considerations as automation is incorporated. Small and family farms in particular account for 90% of all U.S. farms and may require different solutions.

> *"AgTech is specifically designed for larger farms but the need is even more urgent for smaller farms... we don't need 'faster horses' or a bigger more expensive tractor. We need autonomous mobile platforms that do farm tasks and collect data for soil health, yield prediction, early pest detection and optimal productivity. Small farms need labor saving devices that allow the solo farmer (who often ends up being the farm worker too) to achieve higher profit margins."*
>
> ***– Lalitha Visveswaran***
> *California small acreage urban farmer*

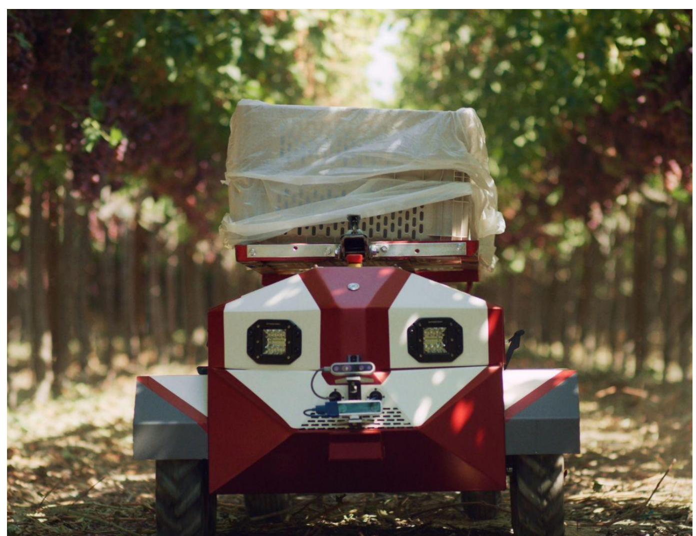
Scythe Robotics recently launched its commercial-grade autonomous mower.

New opportunities for farming robot fleets

Farming operations utilizing drones will need to make sure that the drones can fly autonomously, and beyond visual line of sight (BVLOS), as well as be able to avoid any obstacles in the sky. Many modern commercial drones are deploying recharging stations to allow drones to land and recharge without human intervention; these systems must also be powered and protected from the environment.

Apart from drones and more automated milking/feeding systems, many of these agriculture-based robot systems are still in the early stages of development. Once many of these individual robot systems complete their proof-of-concept projects, the next step for many farms will be to increase the amount of robots used in an operation, or explore the idea of adding different robots for the farm. For example, if a farm is successful with an automated, driverless harvester, they might next deploy an autonomous tractor or autonomous sprayer to use in their operations.

Whether a farm decides to add a new piece of equipment from separate robot vendors, or wants to scale their operations to add additional systems in different locations, a coordinated orchestration system will be needed for these farms to make sure automated systems can communicate with each other – not just to avoid each other in the field, but to share data and perform other tasks. For different robot types, this will require some kind of interoperability standard for communication purposes; fortunately, many groups are currently working on creating such standards just for this purpose.



Future Acres harvesting robot

For companies looking to expand their fleets with the same robot, orchestration of systems is still required, not just to handle consistent monitoring of a robot's vital statistics, but also to make sure those robots are not interfering with other robots.

Even when robots are set up, configured and trained correctly, they will still often make mistakes. The most common error with autonomous mobile robots in indoor environments centers around localization, in which a robot doesn't know where it is relative to its environment, causing it to stall or become unable to complete a task. Things like unexpected obstacles, or light reflection can cause some of these errors. In outdoor environments, many systems rely on GPS environments and other Internet of Things (IoT) sensors that can provide more precise and accurate location information. But in cases where GPS localization errors could be off by up to 20 meters, precision accuracy technologies are needed to supplement GPS.

Robots experiencing errors are called **autonomy exceptions**, and even the most advanced robots can experience these – sometimes even several per hour per day. While one or two exceptions on a single robot can usually be handled, multiplying those by multiple robots ends up becoming an exponential problem without the right system.

Planning and monitoring autonomy exceptions and bridging the autonomy gap (the point at which more effort is needed to achieve higher autonomy), is one of the main goals for RobOps platforms like InOrbit. Making sure robots can react, or at least alert a human operator (either at the location or even remotely) is a key component of a reliable RobOps system.

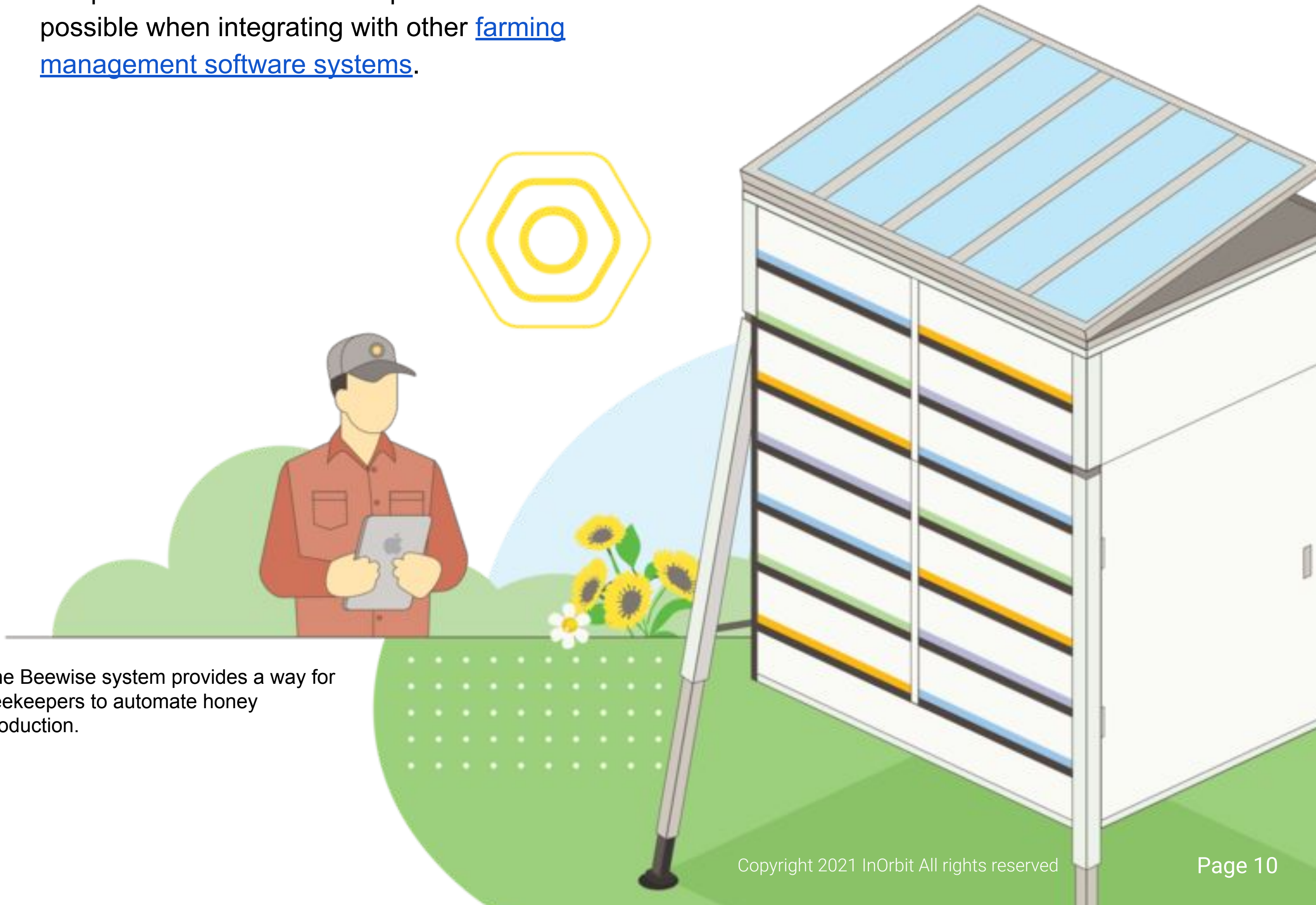
Bear Flag Robotics, recently purchased by Deere & Company, are autonomizing tractors.

RobOps in agriculture

Moving beyond just reacting and responding to problems requires a different set of capabilities in order to achieve further productivity enhancements. Robots, just like farming equipment, must be regularly tuned. Robots can generate massive amounts of data, which can be used to drive continuous improvement and even more optimization. This requires advanced tools.

InOrbit removes the complexity from data collection, aggregation and analysis with a cloud-based platform built specifically for optimizing robot fleets ranging from a few to thousands of robots. The goal is to maximize the potential of every robot, so companies can achieve a faster/better ROI from their automation infrastructure, without needing to hire an army of robotics experts.

At InOrbit, we connect robots to the cloud and enable advanced orchestration of their specific tasks. For example, this means an automated tractor can be told not to enter a particular field until the weeding robot has completed its task. More complex orchestration is possible when integrating with other farming management software systems.

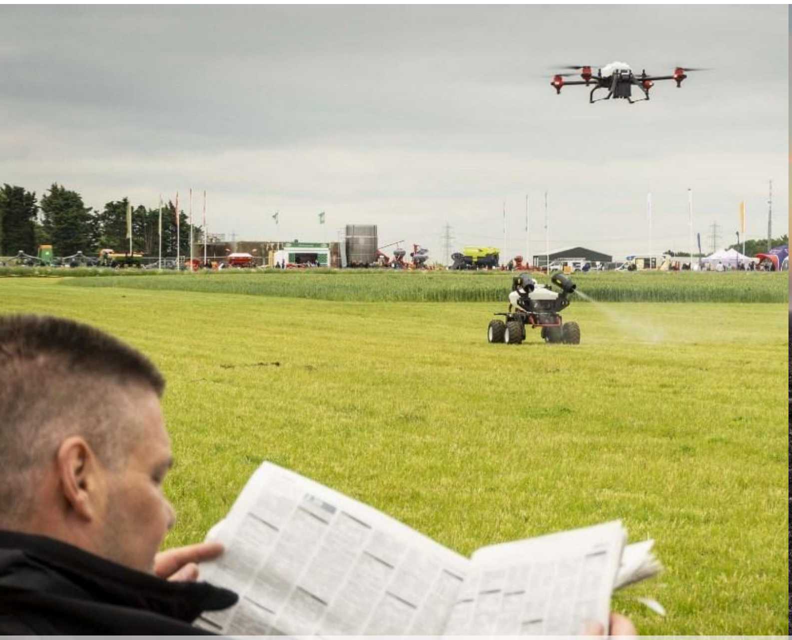


The Beewise system provides a way for beekeepers to automate honey production.

The need for a system that can orchestrate heterogeneous robotic fleets is becoming increasingly mission-critical. Success means being able to quickly identify, react and adapt to changing conditions in almost real time, or even better anticipate and avoid problematic situations, with robots and humans working together to create operational efficiencies.

The ultimate goal of orchestration is to create harmony between a farming operations workforce and its robot workers. Companies that invest in these innovations today establish a competitive advantage by driving productivity, managing labor cost and availability, and improving resilience to various evolving workplace challenges.

If you'd like to learn more about how InOrbit can help maximize the potential of every robot in your farming operations, visit inorbit.ai/agtech



XAG Drones and robots demonstrate abilities in the U.K.

Photo credit: Deere & Company