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# Robot-as-a-Service for Smart Connected Agriculture

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Agriculture is facing the perfect storm. Events in recent years have created urgency for growers to change the way they have been conducting their business for decades. Most markets are moving quickly to data-driven methodologies and implementation of automation tools to increase effectiveness and potential revenue. Yet the agriculture field was not ready to make the move until climate change, farm labor shortages, ever-increasing input costs, and eroding profitability became urgent motivators for farmers to take new steps toward building resilience for the future. One of these steps is the adoption of autonomous machines that take the smart-connected farm to the next level.

Smart connected agriculture is a term frequently used to describe the rapid technological evolution taking place in agriculture across the globe. Some have referred to agriculture as one of the last industrial frontiers to embrace technology, but this is far from being the case. Many of us are familiar with the relatively recent features of lane control in our automobiles, yet our farmers have been working their fields, planting seed, and harvesting for over twenty years already using sensors, computers, and GPS to provide sub-inch lane control accuracy in their fields. Farmers can map the optimal path for their machines and set them loose with an operator on the seat. This person's function is then to observe as tractors and harvesters carry out their efficient, automated tasks and gather valuable agronomic data that can be used for farm management decisions with a greater financial return.

## Advancing technology at a critical time

The need to continue to advance technology in agriculture comes at a critical time as the industry is on the front line of enormous global challenges. Changing weather patterns are narrowing the windows of farming operations. The uptime of machines is paramount. Training and retaining

skilled labor add to the challenge. According to research for the USDA by North Carolina State University, led by Al Gutierrez-Li, "The agricultural labor supply in the United States has declined over the last three decades. Farmers across different states and crops have reported experiencing difficulties recruiting and keeping workers every season. The problem has persisted despite wage increases, improvements in working conditions, additional worker benefits, and the introduction of new technologies."

With climate change, land, water, and other resources will come under ever-increasing pressure. Pesticide and fertilizer costs have increased exponentially as supply channels are challenged. Today, there is an even greater need to innovate, so that farmers can produce more crops with fewer resources. One solution is to adopt autonomous machines on the farm by way of tractors and implements that can perform with greater accuracy and precision, reducing input costs, increasing return on investment, and addressing the challenges of labor availability and rising costs.

## Enabling flexibility, performance, and precision

There are a number of different business models for autonomous products. Some ag tech companies are offering robots to perform only specific tasks on the farm, like weeding or harvesting fruit. Others have developed solutions that the farmer needs to learn to operate upon purchase. The robot-as-a-service (RaaS) approach uses tractors that the farmer already has on the farm, and applies the hardware, software, and sensors for communication and navigation. The tractor can be driven manually or operated autonomously. In autonomous mode, the tractor is capable of multiple operations, such as mowing, discing, or spraying. This business model provides the farmer with the flexibility of a conventional tractor and the performance and precision of a robot.

Companies using this model understand that transforming a farm from tractors and machines with operators to a fleet of autonomous tractors under supervision is a big step, and one that needs a trusted partner—not just a provider. The approach placesthe farmer in the center and supports him through the operational as well as the mindset transition.

## Beginning the journey

Every farm is different, and each field has unique characteristics, so the goal of this business model is to join the farmer on the autonomous journey. The first step for any prospective customer is to conduct a site survey and to ensure that the layout of the fields is conducive to autonomous operation. During the first season on the farm, the autonomous functions are monitored with an operator on the tractor for an extensive period before moving to the next step of remote supervision of the tractor, or a wider fleet of machines. The approach also consists of on-the-job training for the farm staff and ongoing responsibility for any service, hardware, or software updates to the machine over time.

The technical development work to enable seamless, autonomous function in the agricultural environment is significant. The research and development team takes time to gain a deep understanding of the challenges in the new setting. Agricultural settings have their unique

scenarios, including different crops, changing soils, field topography, and farm obstacles such as buildings, poles, and even beehives.

The first step for the development team is to design military-grade hardware that can perform accurately and consistently—and for long periods of time. The hardware must require low maintenance yet remain affordable. The development team then makes the robot tractor aware of the new environment and how to safely and accurately navigate while learning how to recognize and respond to changing scenarios, including different crops, crop spacing, different soil types and conditions, and those obstacles that differ from the autonomous applications solutions in the urban environment.

To achieve this, vast amounts of data need to be collected covering all the scenarios, and over an extensive period. Next, by using multiple innovative communication solutions, the robot tractor can be connected to modern cloud systems to collect data, monitor, and create deep learning over time. This is a process that opens the door for further operating efficiency opportunities. Finally, the autonomous solutions can be applied to multiple tractor makes, which requires a higher level of collaboration and data-sharing capabilities to bring a full solution to the end customer.

Autonomous tractor fleets create new high-tech-oriented positions, providing new opportunities in any grower's farm that will increase job diversity. No longer are operators placed in a noisy, dirty environment. Additionally, future employees' physical abilities are no longer a limit. New skills and expertise can be learned on the farm. Tomorrow's tractor operators have the opportunity to learn field mapping and fleet monitoring from the comfort of the farm vehicle or office.

Running the farm's tractor fleet autonomously also brings other powerful benefits for the farmer. Each of the tractors can gather data during operation and each machine is connected. Through artificial intelligence and powerful machine learning algorithms, the tractors are able to learn how to optimize the performance to the conditions at a speed and fidelity that is impossible to match with an operator.

Smart connected agriculture is changing the way that food is produced. Its rapid advancement comes at an ideal moment during the perfect storm that agriculture is facing. The International Food Policy Research Institute has stated "the world's population is expected to reach 9 billion by 2050. Climate change, population, and income growth will drive food demand in the coming decades." Food scarcity is becoming an urgent issue that has pushed companies around the world to find a solution. Today, we have pieces of the solution already working in farmers' fields, and every day more farmers are being introduced to the possibilities of the 21st-century sustainable autonomous farm.