



Robotics & Automation on the Farm

Food & Agriculture Deep Dive Series

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Executive Summary

For years, farmers, entrepreneurs and investors have discussed and debated the future of the farm, and in particular, the role robotics and automation can and will play in today's farm and that of the future. It would suffice to say that over the last couple hundred years, farming has become significantly more mechanized and automated than it is given credit for, but it is also understood that agriculture as a whole, tends to lag behind other industries in terms of digitization & automation.

However, today, lack of affordable and available labor (particularly in specialty crops) alongside significant advances in robotics, computer vision, artificial intelligence and internet connectivity are creating a unique environment encouraging the adoption of advanced robotics on the farm, indoor & outdoor. From self-flying UAVs to robotic harvesters to autonomous tractors, more and more ag-tech robotics startups are releasing or close to releasing commercial products.

The question is not so much that reliable, low-cost automation and robotics has the potential to impact farmer profitability, output and quality, but more-so whether or not this will happen in the next few years, or in the next 20. On this week's Deep Dive, we will discuss the ways in which automation and robotics are positioned to impact farm management practices and the potential opportunities, strategies and challenges associated with the development, implementation and commercialization of these solutions.

A Thank You to Our Guests



Bakur Kvezereli
Founder & CEO
ZTractor



Charlie Andersen
Founder & CEO
Augean Robotics



Mark DeSantis
CEO
Bloomfield Robotics



Farm Robotics

Definitions & Trends

Agriculture in Need of New & Urgent Solutions

Key Trends

Farm Labor Shortage

Decline in Key States

State	Drop in Number of Field and Crop Workers, 2002-2014	Percent Size of Field and Crop Workforce Shrunk
California	-87,219	-39.4%
Colorado, Nevada, and Utah	-4,244	-36.7%
Alabama, Georgia, South Carolina	-6,956	-26.9%
New Jersey, Maryland, Pennsylvania, Delaware	-5,716	-19.5%
Florida	-8,504	-18.5%
Michigan, Minnesota, Wisconsin	-4,434	-14.9%
Arizona, New Mexico	-1,853	-14.0%
North Carolina, Virginia	-3,798	-13.4%

Labor Shortage Costs to the U.S. Economy

\$3.1 billion in additional fresh produce sales per year for growers.

\$2.8 billion in additional spending each year on related services like transportation.

41,000 more American jobs in non-farm sectors.

	Share imported, 1998-2000	Share imported, 2010-2012
Fresh Fruits	14.5%	25.8%
Fresh Vegetables	17.1%	31.2%

- From 2002-2014, the US saw a decline in 146,000 field and crop workers, alongside a 12% increase in average wages. It is estimated that \$3.1B in additional fresh produce could have been achieved with the necessary labor, and that such shortages are leading to substantial increases in fresh produce imports.

Demands of Precision Ag



- Existing farm equipment manufacturers may be limited in their ability to fully achieve precision agriculture.
- There may be opportunities to both integrate with existing equipment as well as disrupt current incumbents

Source: <https://www.newamericaneconomy.org/issues/agriculture/>

Advanced Robotics More Accessible Than Ever Before

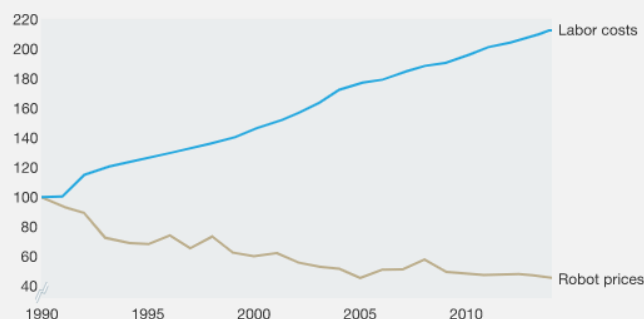
Key Trends

Reduced Cost

Robot prices have fallen in comparison with labor costs.

Cost of automation

Index of average robot prices and labor compensation in manufacturing in United States, 1990 = 100%



Source: Economist Intelligence Unit; IMB; Institut für Arbeitsmarkt- und Berufsforschung; International Robot Federation; US Social Security data; McKinsey analysis

McKinsey&Company

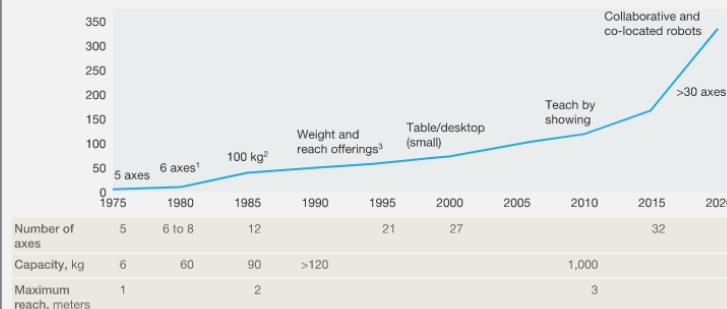
- In all, our ability to produce & develop robots is going down in cost, while overall labor cost has continued to increase.

Increased Capabilities

The increasing variety, size range, and capabilities of robots have driven market growth.

Growth of robots on the market

Base quantity SKUs



¹Allows arc welding, adhesives dispensing, machine loading.

²Spot welding, materials handling.

³All application areas; right size for the task.

McKinsey&Company

- The capabilities of robots have moved far beyond performing highly uniform tasks in low-variable environments. Robots can now perceive & learn.

Key Challenges Moving to Ag

- Trust / Reliability: particularly for outdoor agriculture, the burden of proof to fully replace existing solutions is very high.
- Implementation: can solutions be owned & operated by a non-robotics expert?
- Cost / ROI: ROI must be demonstrable & have network effect
- Customer Access: Current equipment manufacturers have a very strong hold on existing install base

Source: <https://www.mckinsey.com/business-functions/operations/our-insights/automation-robotics-and-the-factory-of-the-future>

Business Model: Buy or Subscribe?

Dealer Networks, Service & Financing



Traditional Model

- Major agricultural hardware sold through equipment dealer, likely with some provided financing and after-sales technical support.
- Growers like because cost stream is not perpetual
- OEMs like because they control the install base

Robotics as a Service (RaaS)



New Model

- New tech is highly complex and specialized, and doesn't make sense to own. For labor applications, grower is charged piece rate, and in others, on a per acre other scaled basis
- Robotics companies & investors like because revenue streams more consistent, business model potentially disruptive
- Growers unsure if they like it depending on use case.

Discussion: Advanced Robot or Simplified System?

Table Top vs. In Soil Strawberry Farming?



Indoor Farming vs. Outdoor Farming



What is the case for simply introducing robotics & automation into less complex environments?



Technology Innovators

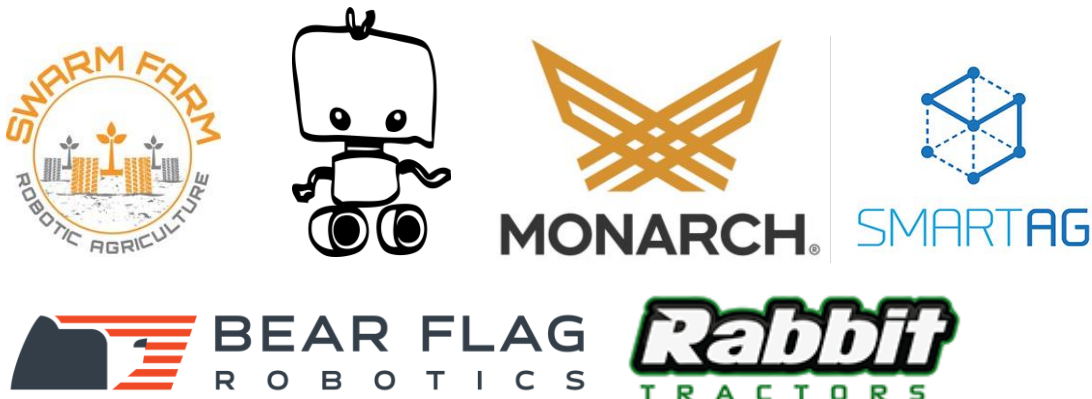
Opportunities & Challenges

Discussion: Numerous Areas of Innovation

- 1. Harvesting**
- 2. Weeding / Spraying**
- 3. Pest Control / Crop Health**
- 4. Food Safety**
- 5. UAVs & Applications**
- 6. Autonomous Tractors & Vehicles**

Autonomous Tractors

Startup Solutions



Startup Highlight



State of the Industry

- Numerous incoming players including completely new hardware & retrofit.
- Incumbents working on internal solutions (CNH, AGCO, etc.)

The Opportunity

- Some reduced labor costs
- Greater connectivity to collect real time field data
- Reduce soil compaction
- Smaller, more agile machines

Challenges Remaining

- Maintenance needs for advanced autonomy
- Competing with existing retailers is a major hurdle
- Do core competencies of the farmer change?

Crop Health & Data Solutions

Startup Solutions



AMERICAN ROBOTICS



State of the Industry

- Lots of aerial scouting and some sub-canopy scouting being explored
- Solutions today are more often assisting crop health experts than replacing

The Opportunity

- Highly valuable data at the plant level
- Camera / advanced imagery costs continue to decline
- Precision pest/herbicide, yield prediction, etc.

Startup Highlight



Challenges Remaining

- Do solutions need to be good enough to replace humans? Will they ever be?

Harvesting Solutions

Startup Solutions



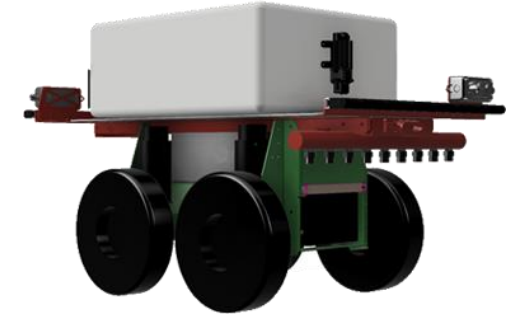
State of the Industry

- Numerous high-profile startups in specialty targeting harvest automation
- Major urgency around harvesting services

The Opportunity

- Estimated \$3.1 billion in additional fresh produce available with the right labor
- Opportunity to get tech into the field due to market pull

Startup Highlight



Challenges Remaining

- Automating actual harvesting is very challenging
- Robotics as a service in agriculture has yet to be proven

Incumbent Innovation

Can Corporates Innovate From Within?

Case IH Driverless Tractor



- Both cab and cab-less versions (2016)
- Designed to boost production & productivity while remaining robust.

Project Xaver w/ Agco



- Collaboration between Fendt & Agco
- Small-robot fleet design
- Focused first on seeding

Taylor Farms & Driscoll's



- Taylor Farms has over 40 discrete innovation projects underway
- Driscoll's has deployed dozens of technologies and tested with many startups

Source 1: <https://media.cnhindustrial.com/EUROPE/CASE-IH/autonomous-tractor-technology-shows-way-forward-for-farming-enhancing-efficiency-and-working-conditions/d9d11785-2881-4577-afc2-23e6dadbf91>

Source 2: <https://www.precisionfarmingdealer.com/articles/3200-what-is-driving-the-driverless-momentum-in-the-ag-equipment-industry>

Source 3: <https://www.forbes.com/sites/currentaccounts/2017/03/02/with-farm-labor-getting-scarcer-big-u-s-farms-are-preparing-to-turn-to-robots/#5ca91ca67bb6>



Thesis

Thoughts Going Forward