

# Driving Forces & Logistical Obstacles for Autonomy in Agriculture

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CEO • Autonomous Tractor Corp.  
January 9-10, 2017



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# Introductions



**Kraig Schulz – Co-founder, ATC, President and CEO**  
**20 years of academic and professional work in agriculture and bio-sciences**



**Terry Anderson – Co-founder and Chief System Architect, ATC**  
**Founder of seven successful technology companies including Ancor Communications**

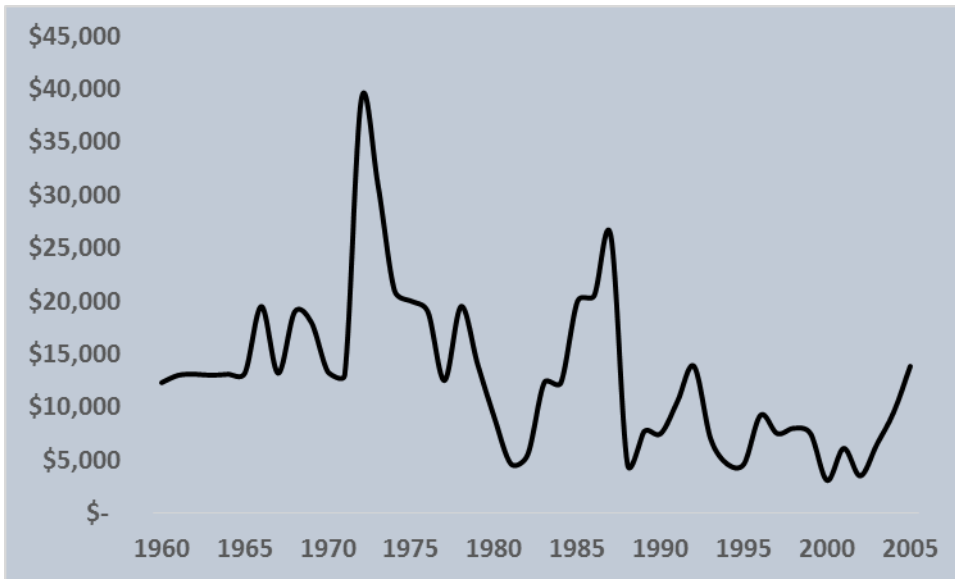


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# We need to reinvent agriculture

*Real on-farm income has been declining for years...*



*Using methods dating back to the Pharos...*



Source: USDA

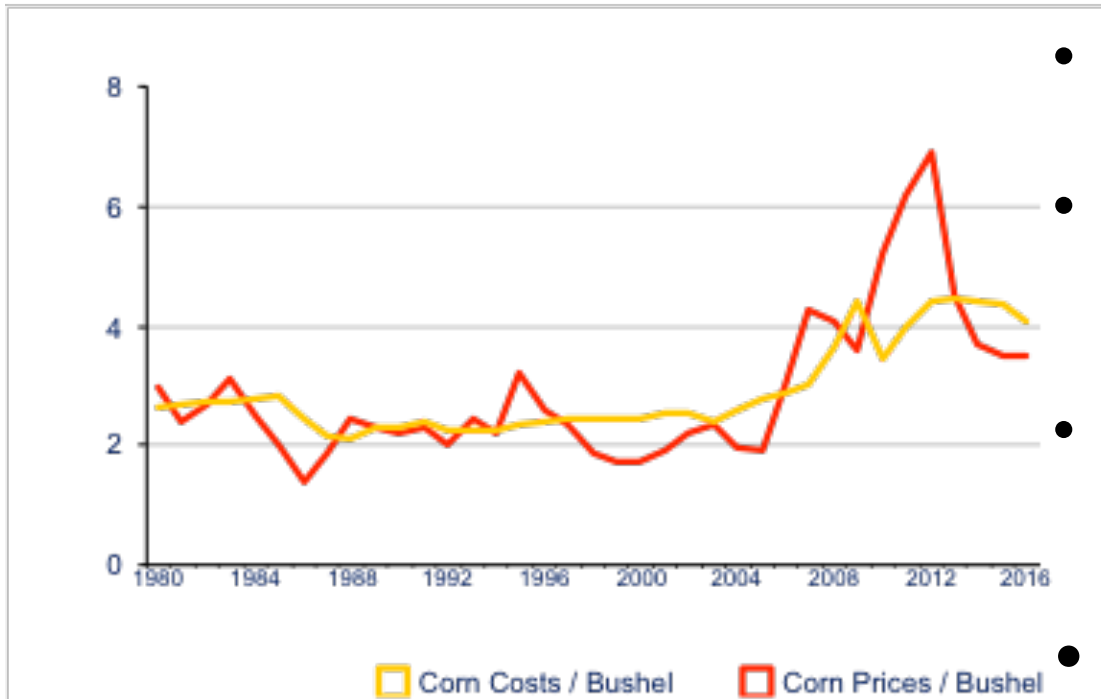


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# Average cost of corn production has risen much more quickly than prices

\$ / bushel



- Average Cost up 60%
- Average Price up 40%
- Average net to farmer = (\$0.01) since 1980
- Prices forecast to be \$3.30 - \$3.70 for next 10 years
- Ethanol boosting prices by about \$1.00 / bushel.

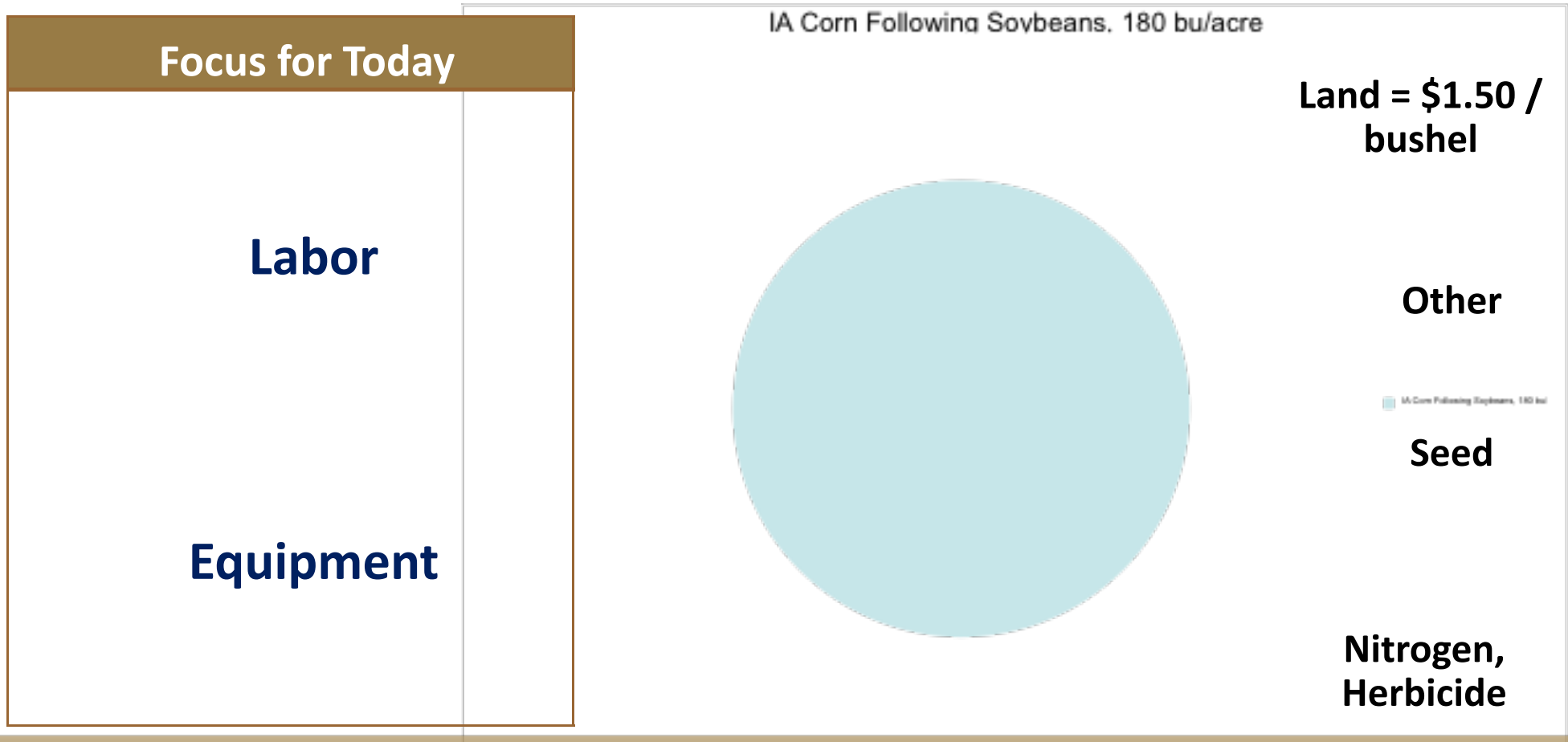
Source: Iowa State, USDA, UC Davis



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# 63% of the costs of production (\$3.99 / bu) are non-land costs



## How can we cut equipment and labor costs in HALF?

Source: USDA



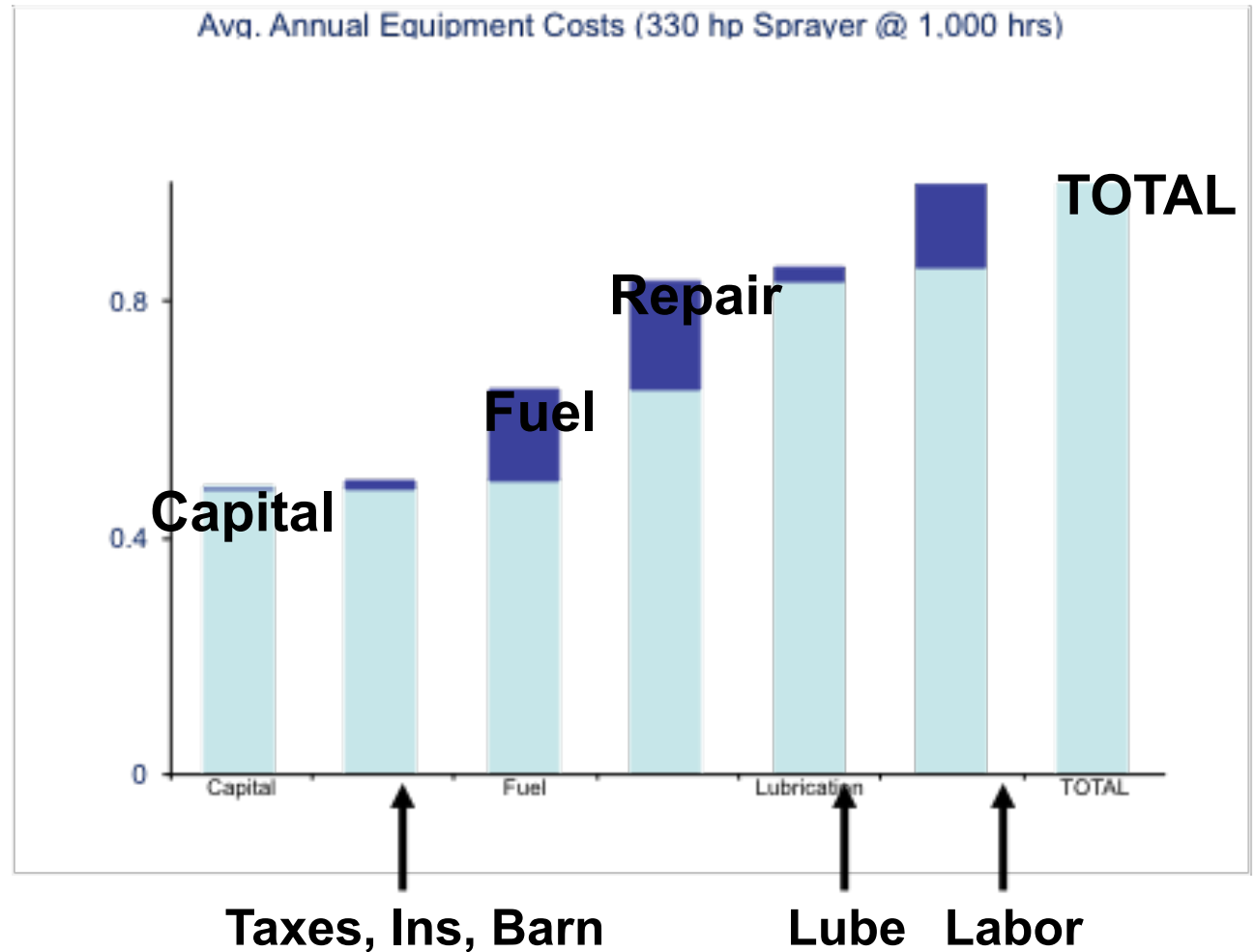
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# Cutting equipment costs in half saves nearly 9% (\$0.36 / bushel)

## Top 3 equipment costs:

- Capital
- Fuel
- Repair



Source: IA State Extension

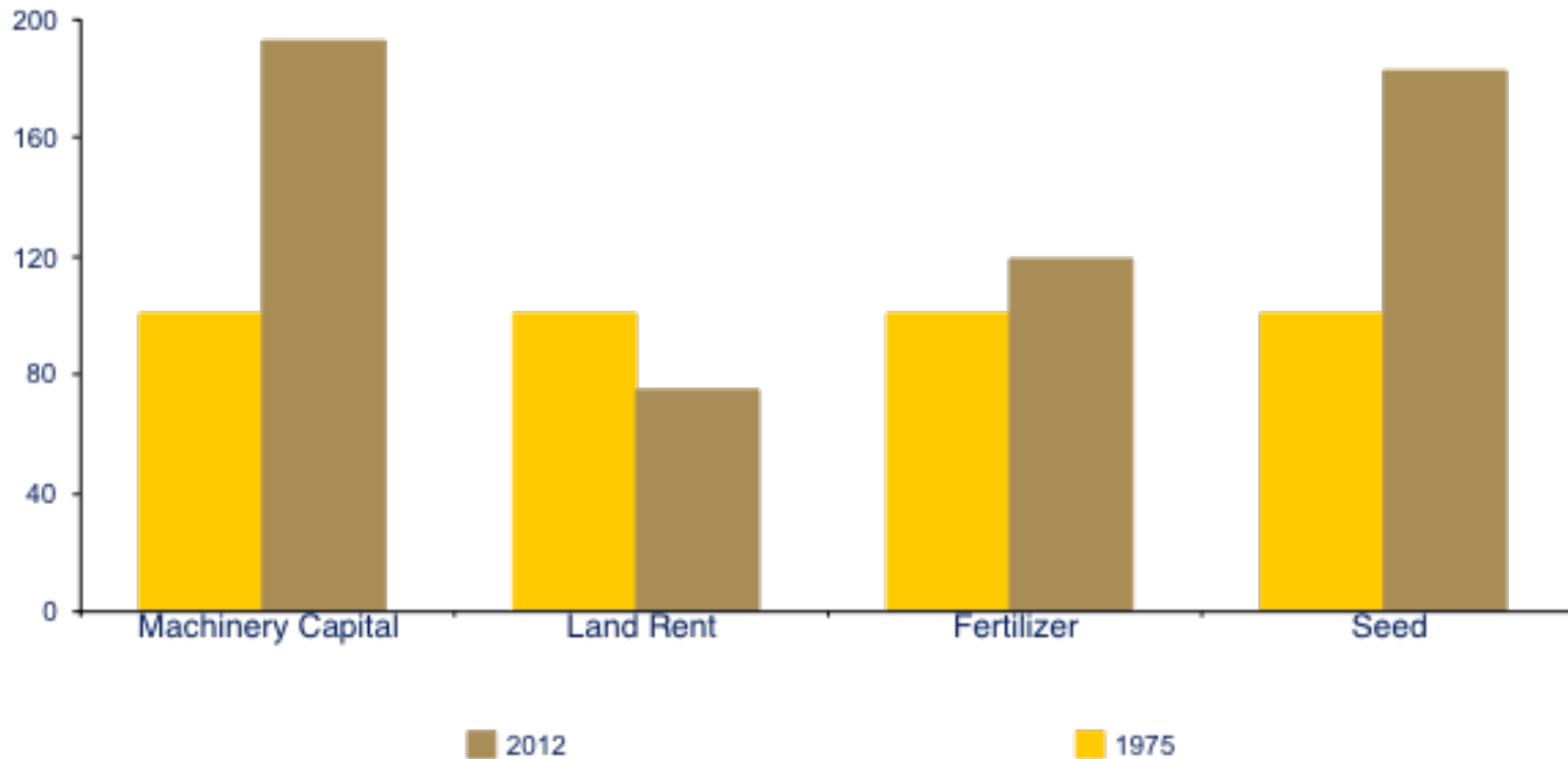


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# Capital: costs of equipment have increased by nearly 100% in 30 years

Production Input Cost, Inflation-Adjusted (1975vs 2012)



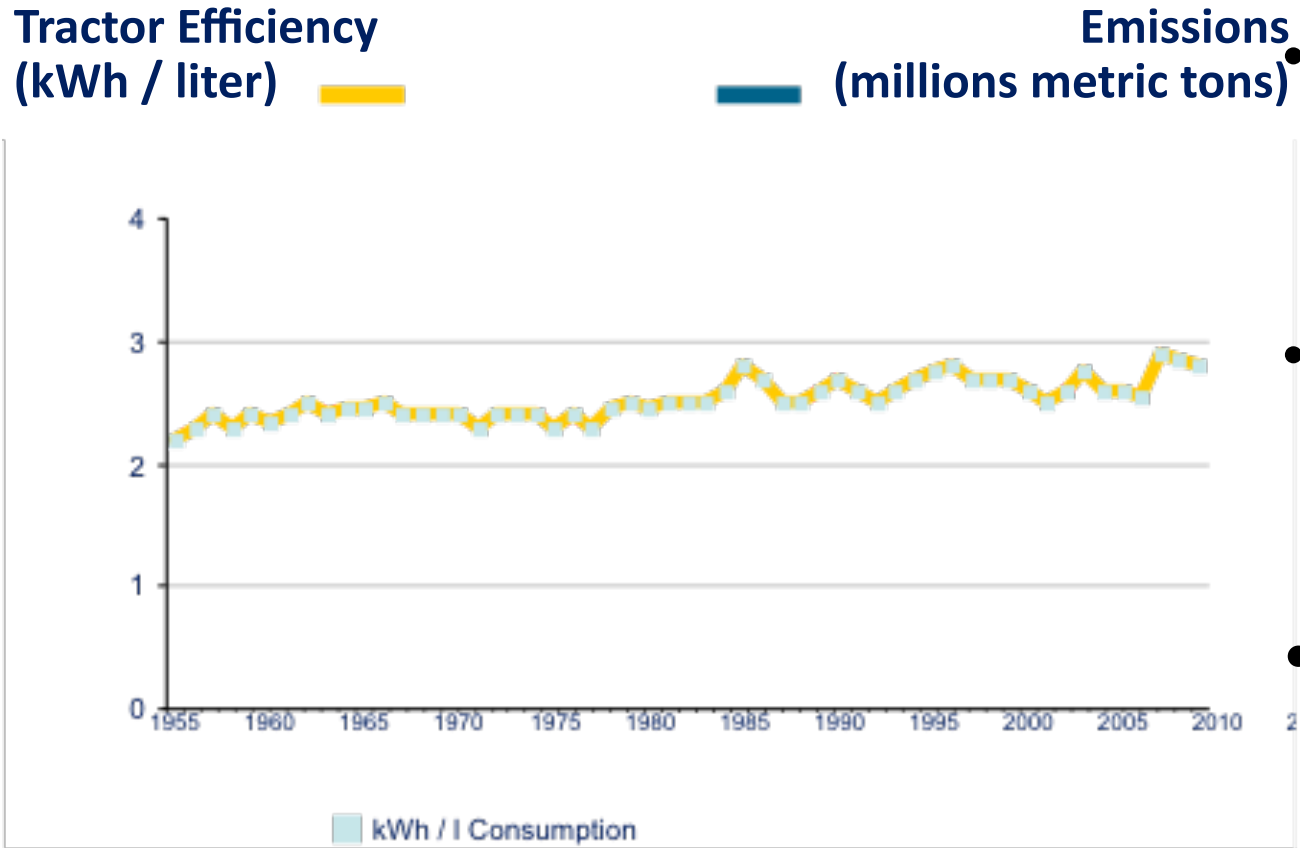
Source: Kansas State



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# Fuel: modest (17%) improvement in tractor efficiency in 60 years



It took 60 years to improve fuel efficiency by 17%

Only 3% improvement in last decade

Emissions up 10% since 1990

Source: Nebraska Tractor Test Laboratory

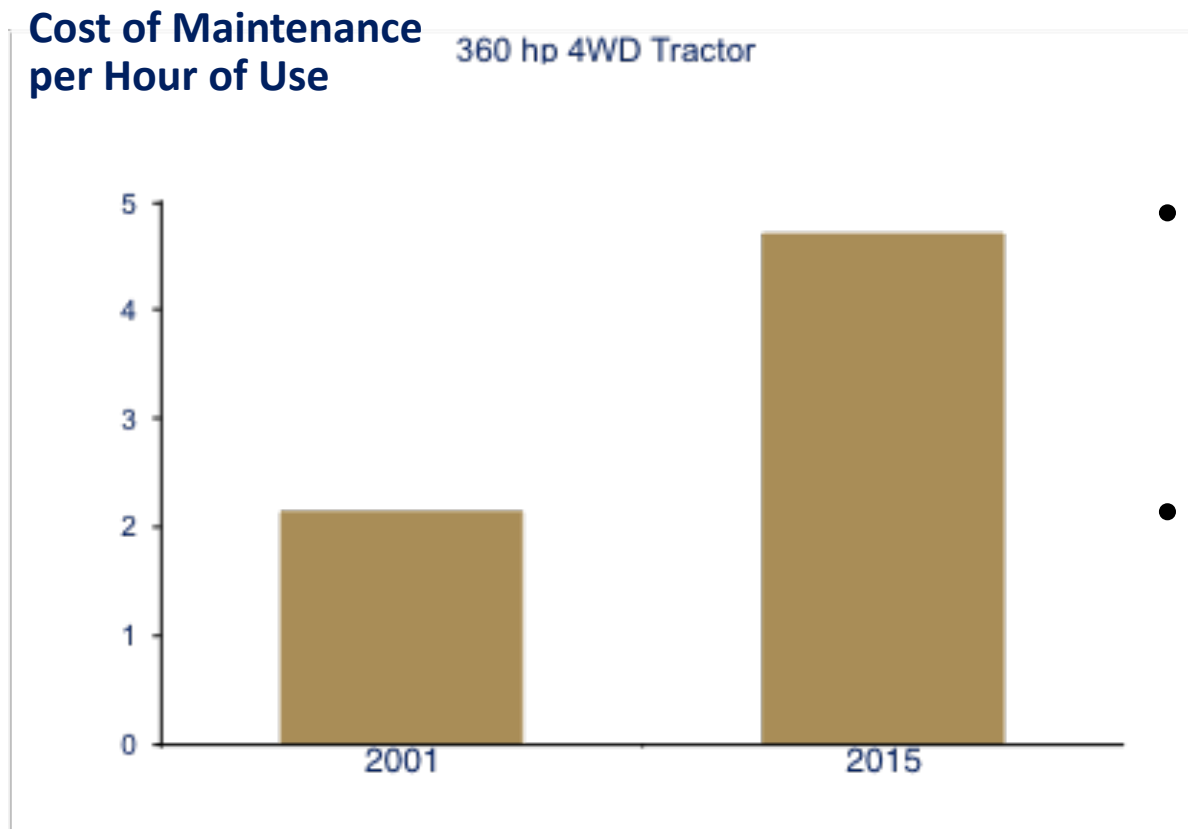


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# Repair: maintenance costs have risen as fast as the price of the equipment



Source: University of Minnesota Extension 2001, 2015  
Farm Equipment, 2014  
Harvest Public Media, 2013

- About 50% of repair costs is labor
- Labor cost rising as equipment becomes more complex
- “The most expensive time we have is if the combine or the corn planter has to stop”

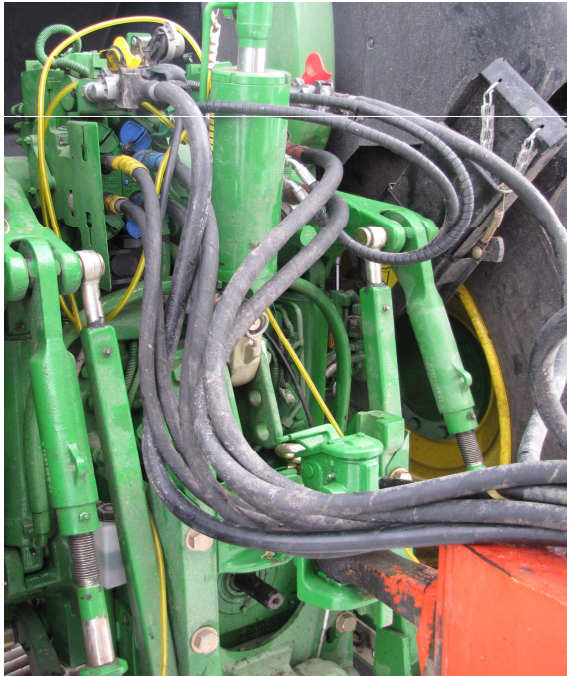


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# Repair: today's equipment is incredibly complex, making repairs difficult

## Hydraulics



## Electronics



“There’s an increasing number of farmers placing greater value on acquiring older, simpler machines that don’t require a computer to fix.”

Machinery Pete

“[...] the vehicle owner receives an implied license[...].”

John Deere

Source: Farm Industry News, Alto for / CAT dealership website, WIRED Magazine  
<http://www.makeuseof.com/tag/nothing-drms-like-deere-farmers-cant-fix-tractors/>



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# Electricity is the solution – “Tesla for Tractors”

*What independent authors say about electric tractors*

Fuel economy: up to 50 percent in fuel economy savings.

Longevity: service life of 30K – 50K hours, almost no maintenance

Simplicity: eliminate wear items, such as the clutch, transmission

Source: <http://knowhow.napaonline.com/farming-technology-trends-hybrid-tractors-coming/>



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# How could electrification of ag equipment help reduce costs?

Simplicity

Precision

Durability

Cost

Efficiency

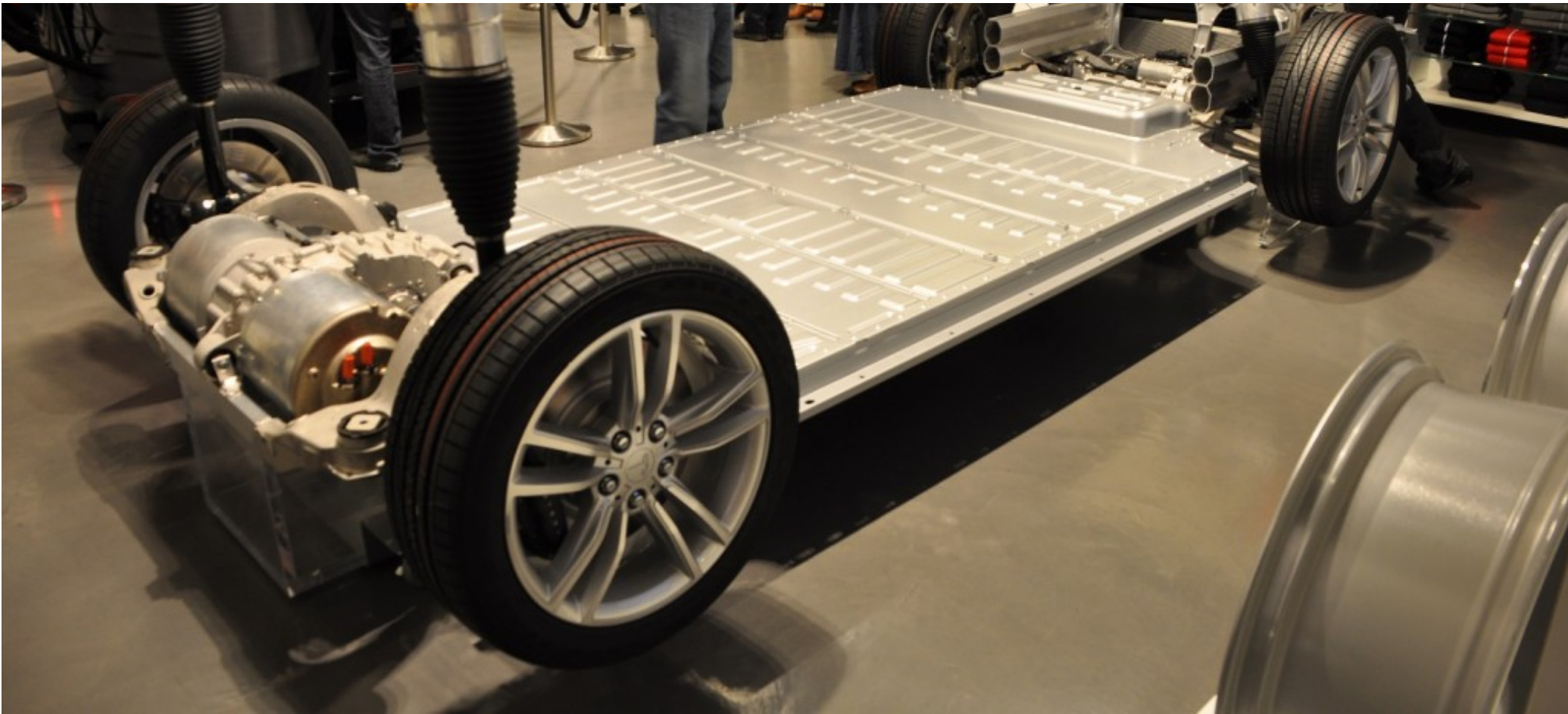
Semi-Autonomy



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# Simplicity – just look at a Tesla



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# Simplicity – electrification can dramatically simplify tractor systems

From

To

20 ECUs  
500,000  
lines of  
code

3,000 feet  
of wire  
200 feet of  
hydraulic  
lines



- 5 ECUs
- 20,000  
lines of  
code



- 200 ft of  
wire  
Fiber-  
optics  
Electric  
actuators

Source: Rainer Hoffman, AGCO, 2006; ATC Estimates



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# Simplicity – two fiber-optic lines can replace the entire wire harness

Immune to interference

8X stronger than copper

1,000X faster

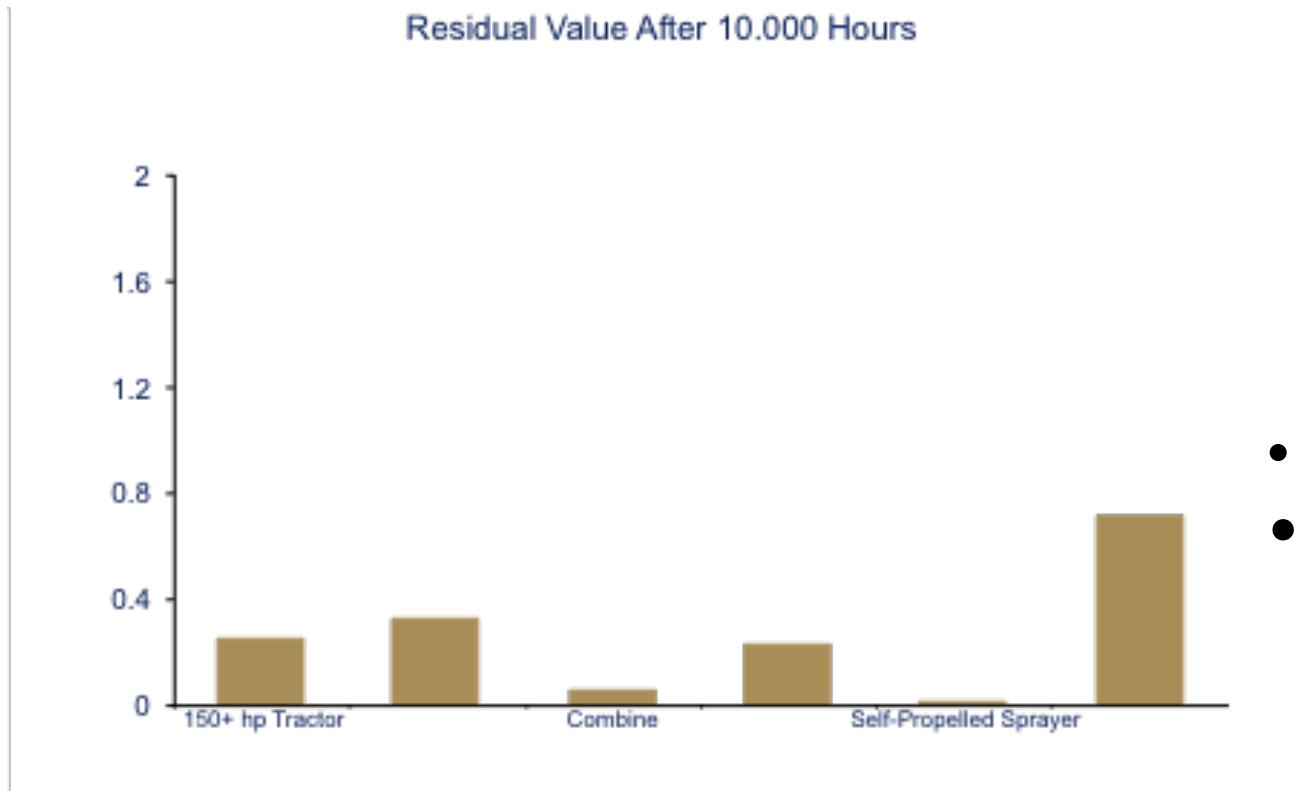
2 connections vs. dozens



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# Durability – electric systems far superior to mechanical or hydraulic



Estimated lifespan  
of a large electric  
motor:

- 29 years
- 200,000 hours

## 150+ hp Tractor

Source: University of Minnesota, Machinery Cost Estimates, 2015  
Electrek, 2016 – Tesla Model S Residual Value after 50,000 miles  
US DOE

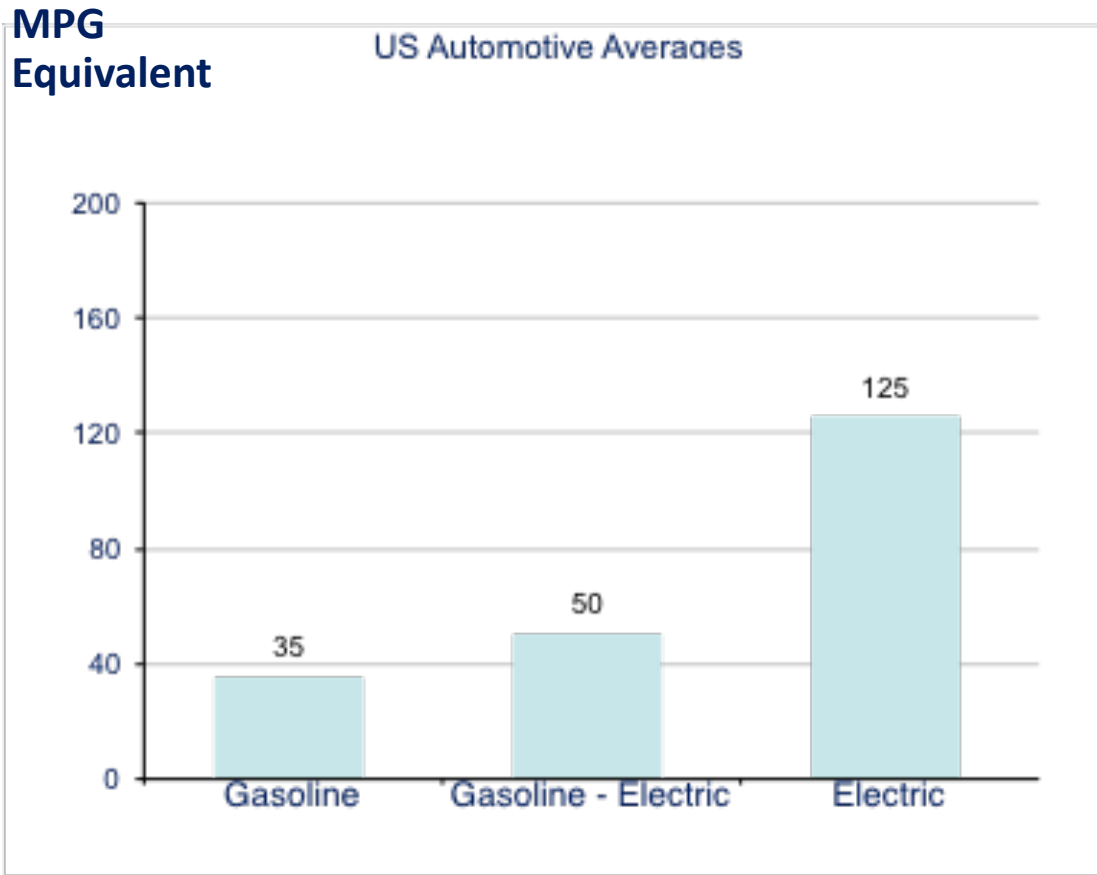


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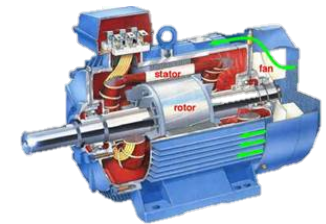
# Efficiency – electric drivetrains are about 30% more efficient than mechanical



## Energy Conversion Efficiency

Transmission  
70%

Electric Motor  
95%



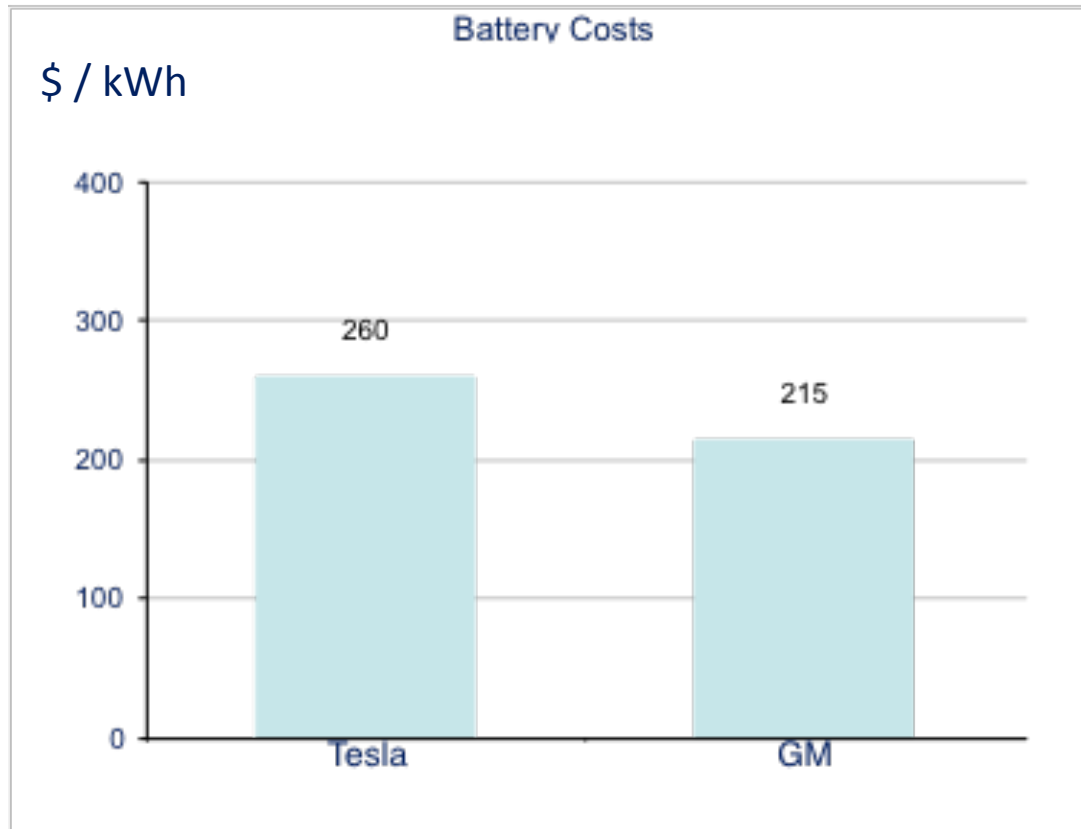
Source: US Energy Information Administration



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# Cost – electric systems can be cost-competitive if we eliminate the batteries



A typical large tractor (200hp) requires about 150 kW

Running the tractor for 10 hours means 1,500 kWh requirement

At current prices = \$350,000 for the batteries alone

Weight of 1,500 kWh lithium ion batteries = 21,000 lbs (5,000 lbs more than a typical 200hp tractor)

Source: Green Car Reports 2015  
L David Roper  
Tractor Data



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# Use Case #1 – JD 4930 HC Self-propelled Sprayer

*Remove*

Hydraulic  
Pumps

Hydraulic  
Wheel Motors

*Add*

250 kW  
Generator

4 Electric  
Wheel Motors

Electronic  
Transmission

Engine, cab controls, booms, wheels, etc. remain unaltered



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# Electrification is happening on today's equipment

Replace hydraulic motors with electric motors



Replace hydraulic pumps with electric generator



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## Use Case #2 – Self-propelled Implements



Fertilizer

Planter

High HP Tractor

“I drag all of this equipment across the field and it just wears my tractor out. I get maybe 4 years out of my tractor and then it is just worn out.”

Producer, Nebraska



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# Example applications for electric drives

*Construction Haul Trucks*



*Small Farm Tractors*



*Large Farm Tractors*

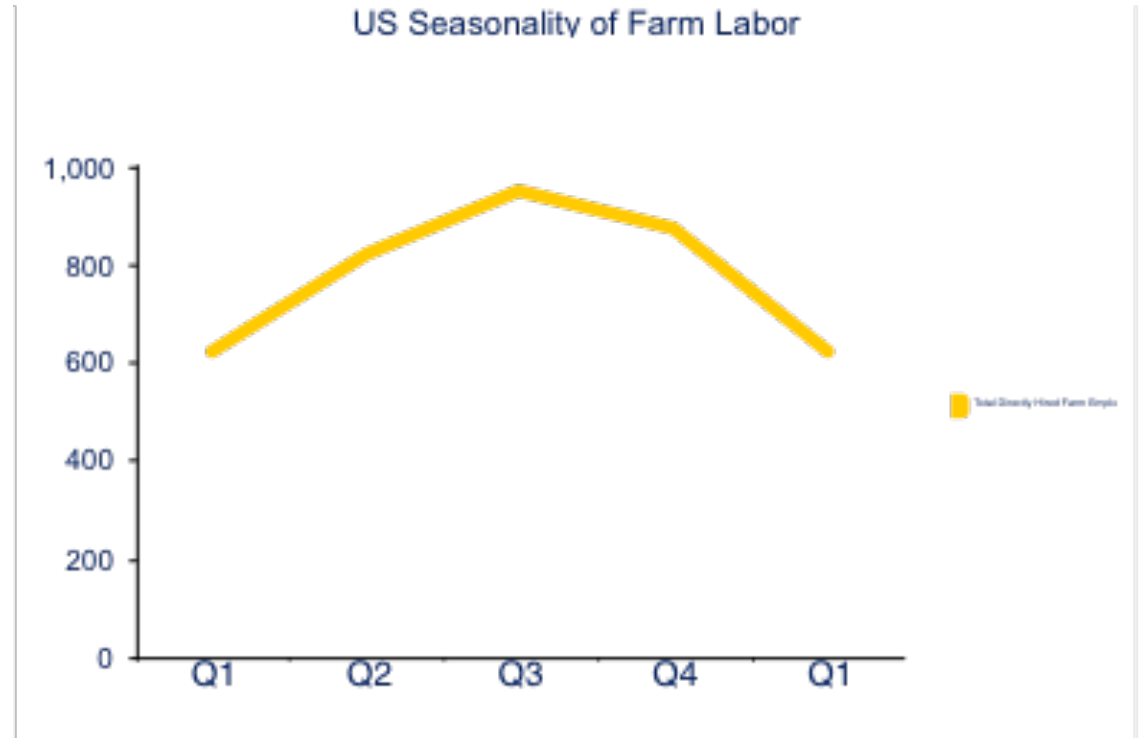


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# Labor – we have a chronic shortage of labor during peak seasons

- Cutting labor costs in half can only save 2.5%
- Improves consistency of operations (lower cost, higher yield)



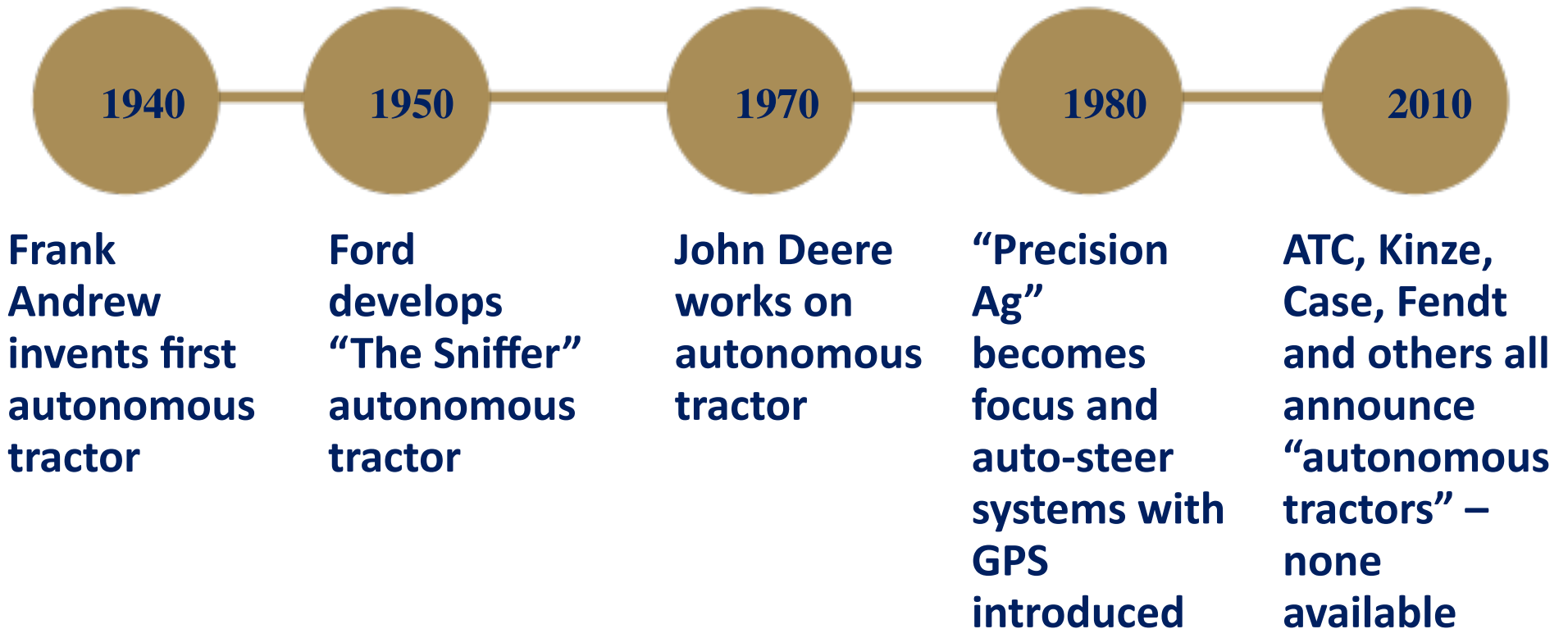
Source: US BLS



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# Labor – we have had autonomous tractors for 70 years so why don't we use them?



Source: Wikipedia



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# Labor – an autonomous tractor itself does not solve the problem



Farmers know how to manage the equipment through a myriad of conditions



Implements, not tractors, actually do the work

Computers are a long way from knowing how to farm



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# Drivers manage exceptions

Farmers report having to get out of the cab to resolve some issue with the equipment 3-5 times per ¼ section

Rocks  
Heat  
Hoses  
Electrical  
Mud  
Hydraulics  
Animals  
Branches  
Hitch Pin  
Residue  
Fire  
Pneumatics  
Refill  
GPS  
Implement

No two trips through the field are ever the same

Source: ATC interviews



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# Semi-autonomy is the answer: equipment works independently, under supervision



**Lower Cost**  
*No tractor, less power*  
*Less labor*  
*Modular power units*



**Greater Precision**  
*Power in wheels*  
*Traction control*



**Digitization**  
*Semi-autonomous*  
*Real-time data collection*



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*Thank you for your time...*



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