Farming with robots

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Harper Adams University

National Centre for Precision Farming

European Union
European Regional Development Fund

AGRIEPICENTRE
Engineering • Precision • Innovation

Harper Adams University

Harper Adams
University

- Founded 1901 by Thomas Harper Adams
- Crops, Animals, Food, Land and Engineering
- *Circa* 2500 students
- Engineering department
  - *Circa 300 students, 20 academics, 10 technical staff*
  - Agricultural Engineering
  - Automotive Engineering (off highway)
  - Mechanical Engineering
  - Applied Mechatronic Engineering MSc
- Research into robotic agriculture

THE TIMES THE SUNDAY TIMES
GOOD UNIVERSITY GUIDE 2017
MODERN UNIVERSITY OF THE YEAR

THE STUDENT EXPERIENCE SURVEY 2016-2017 FIRST PLACE

TEF Gold

WHAT UNI? STUDENT CHOICE Awards 2017 WINNER UNIVERSITY OF THE YEAR

The Queen's Anniversary Prizes
For Higher and Further Education
2017

National Center for Precision Farming

National Centre for Precision Farming

- Agricultural drone training, development & testing
- Autonomous tractor
- Laser weeding and micro droplet application
- Robotic seeding and spraying
- Robotic phenotyping and crop scouting
  - Sub canopy sensing robot
- Autonomous mower
- Robotic strawberry harvesting
- Phenotyping robot for grass
- Hands-free-hectare

Agricultural Engineering Precision Innovation Centre (Agri-EPI)

- Private company based at Harper Adams University
- £18 million government investment in new company hubs to develop Precision Agriculture
- Help the UK's agri-food sector develop with advanced technologies that increase productivity and sustainability.
- Company to company and company to university R&D
- The Centre has hubs in Edinburgh, Harper Adams and Cranfield Universities.
- 27 instrumented satellite farms
- 130 commercial collaborating companies
- ERDF project to facilitate innovation (Marches LEP)

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AGCO Your Agriculture Company
SRUC
Harper Adams University
AG Space
Cranfield UNIVERSITY
AHDB AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD
Kingshay
Harbro QUALITY LIVESTOCK NUTRITION

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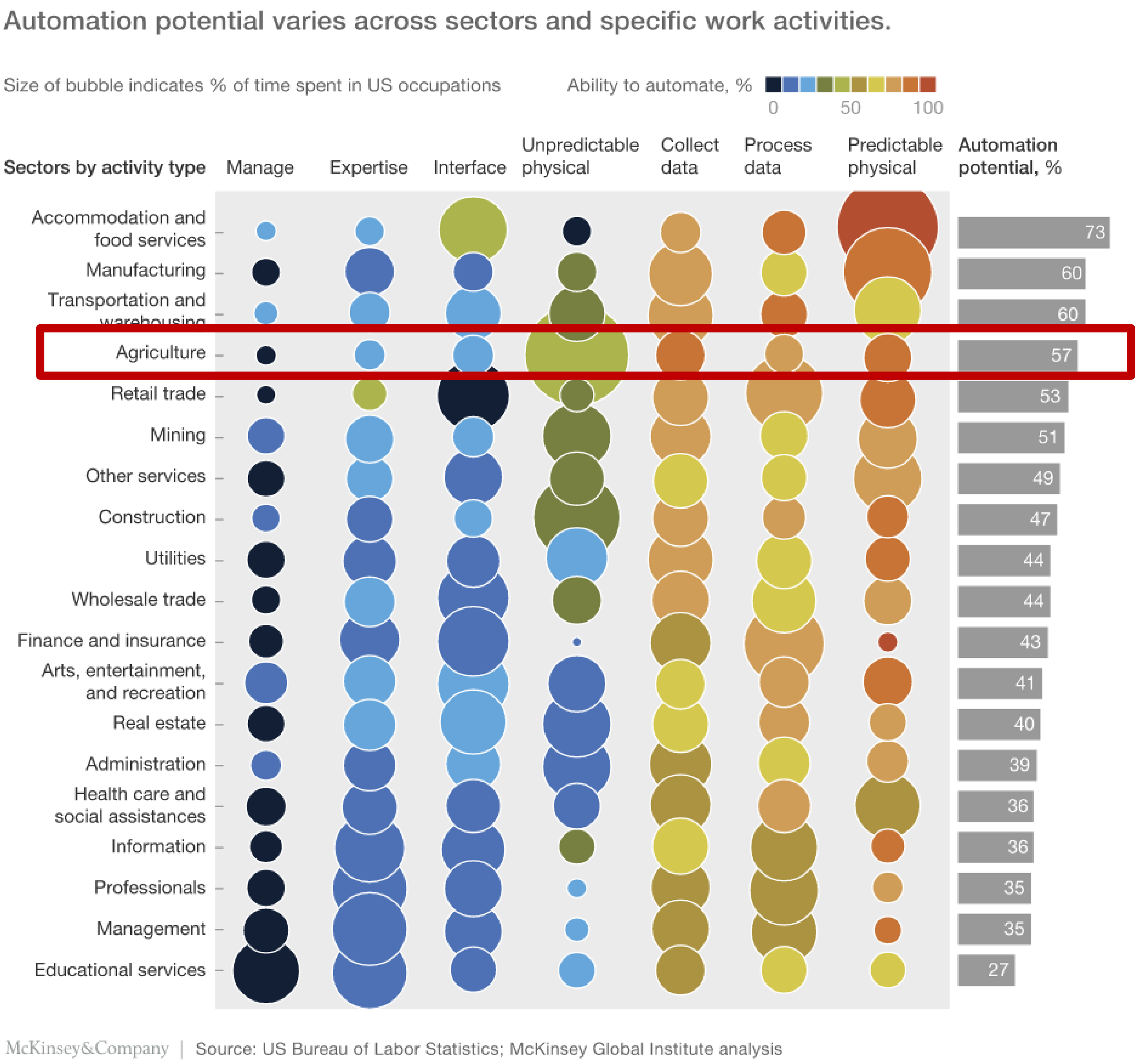
Farming in the future?

- Identify weaknesses in current farming system
  - Modern agriculture uses too much energy
    - Fuel in damaging and repairing the soil each year
    - Expensive chemicals being wasted by going off target and causing pollution
  - Large machines and practices are damaging the soil
    - Compaction and loosening every year
    - Intensive cultivation looses soil organic matter
  - Growth through economies of scale coming to an end
    - Machines have getting bigger due to driver costs but are now at their maximum size
    - Large machines are only good for large fields and small fields cannot use them
- Drivers for change
  - More sustainable food in a growing world population
  - Improve on-farm economic viability
  - Desire to have less environmental impact
  - Tighter legislation from EU and UK
  - Energy prices increase
  - More volatile weather due to climate change
  - More competition from world food prices
- Crop production must become more flexible and efficient
  - Intelligently targeted inputs

Future trends

- Agriculture has a 57% potential for automation



The Perfect Storm in UK agriculture after BREXIT

- No production subsidies
  - Farming subsidies cut like NZ
- Vote to restrict EU labour
  - No seasonal harvesters
  - Higher wages to attract British workers
- Devaluation of pound
  - Good for our exports
  - Bad for imported inputs
- Lower sustainability
  - Growers now planting less
  - Growers moving crops to cheap labour

- Technology alleviation
  - Some tasks can be automated
  - Significantly reduce the costs of production
  - Could be made in the UK
  - Move from Precision Farming to Robotic Agriculture

Farming systems

- Currently like an industrial production line
  - Maximising production (yield)
  - Large tractors doing the same work everywhere
  - Based on blanket application of energy (fert, spray,…)
- Need to move to flexible manufacturing
  - React to changes in real-time based on current conditions
    - Weather, growth, prices, legislation, incentives
  - More information intensive
    - Maximise gross margins
    - Manage risk
    - Minimise environmental impact
    - Automation

Economies of scale

- Big tractors and big implements
  - Increasing work rates and economies of scale reduces;
    - Driver costs
    - Cost and time per hectare
  - Large capital investment
  - Reached maximum size due to railway tunnels
    - No more savings through larger economies of scale
  - Good for large fields, cannot be used in smaller fields
    - Small to medium size farms and fields have the greatest potential for increased production with appropriate tech.

Limitations of big machines

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- One size fits all
  - Large tractors often doing small work
  - Rarely using full power
- Boys toys
  - Big shiny tractors are always impressive
  - Small smart robots are also fun!
- Need for speed results in a self fulfilling prophecy
  - Small working window needs a bigger machine
    but the bigger the machine the smaller the working window.
  - Horsepower does not help when weight is the problem
- We cannot change the soil or the weather
  but we can change the tractor

Compaction

- Up to 90% of the energy going in to cultivation is there to repair the damage caused by large machines
- Repeated damage year after year
  - Plough/damage, plough/damage, …
- Economic cost of compaction in England and Wales : c. £0.4 bn/annum (Morris et al. Cranfield University, 2011)
- If we do not damage the soil in the first place, we do not need to repair it
- Natural soil flora and fauna produce the ideal soil structure (let the worms do the work)
- Move towards Controlled Traffic Farming and ultra light machines

Four phases of mechanization

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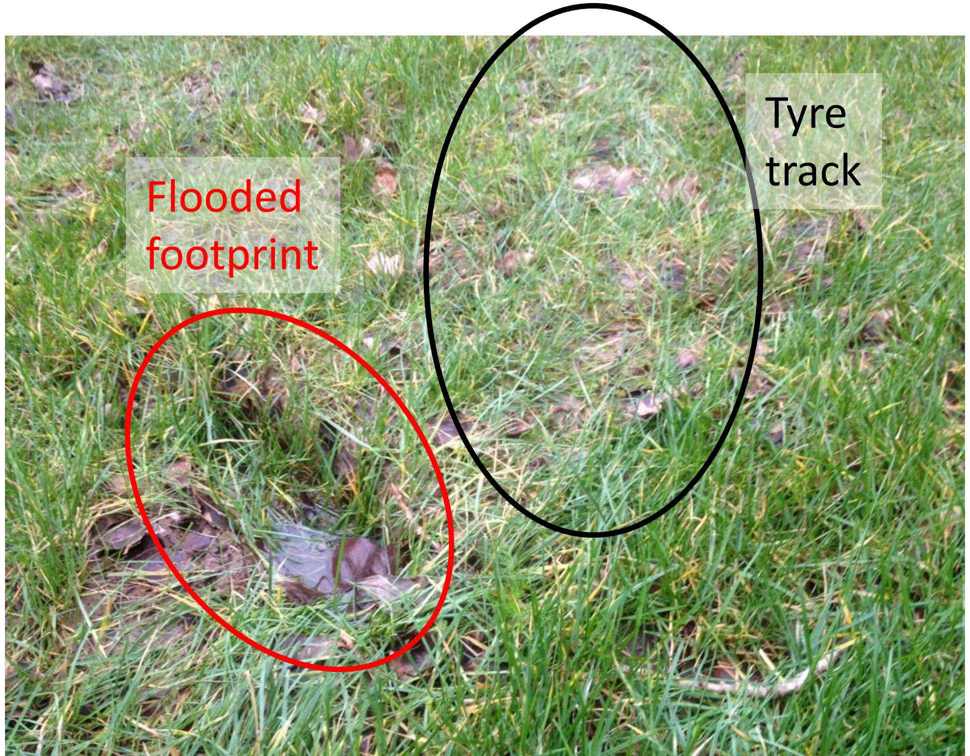
Robotic seeder

- Ultra light, zero draught force
  - No agronomic compaction
  - Put seed into the ground in any weather
- Micro tillage
  - Cultivate for each individual seed position
- Use vertical or rotary seeding methods
  - Punch planting
- Seeding depth to moisture
  - Improve germination rates
- Permanent planting positions
  - Same place each year

Ultra light seeding robot

- Less than 40kPa (6PSI) under the contact patch
- Does no agronomic damage even at field capacity
- Can seed the ground in any weather conditions



Crop scouting

- Working with agronomists by giving near-real-time data over the whole farm
- UGVs (Unmanned Ground Vehicle)
  - Phenotyping robots
    - Crop trials to evaluate new genotypes
  - Scouting robots
    - Targeted agronomic measurements
- UAVs (Unmanned Aerial Vehicle)
  - Rapid assessment technique
  - High resolution imagery
    - Visible: Crop cover, growth rates, flooding extent, late emergence, weed patches, rabbit damage, nutrient imbalance
    - Non-visible: NDVI, Thermal, multispectral
    - Sensor limited by weight and power

Agricultural Drone Centre

- Part of the NCPF
- Working with
  - Civil Aviation Authority
  - Chemical Regulation Directorate
  - Many drone companies
- Spray testing laboratory to accredit drones to use spray in the UK

Crop scouting; Dionysus robot

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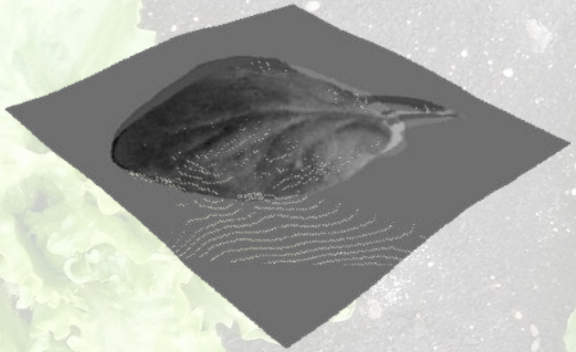
- Crop scouting robot for vineyards
- Build by Harper Adams MEng students for the University of Athens
- Software Architecture for Agricultural Robots
- Thermal camera for irrigation status
- Multispectral camera for nutrient status
- LIDAR for canopy extent and density

Sub-canopy scouting robot

Robotic Weeding

- Hand weeding costs £2000 per hectare
- 80% grass weeds in UK herbicide resistant
- Discussions to ban Glyphosate
  - Do not ban Glyphosate, ban the dumb sprayer wastes the chemical
  - Only apply chemical directly on to the target leaf
- 10 years & $250m for new active ingredients (not happening)
- Physical weeding alternatives
  - Mechanical weeding
  - Micro droplet spraying
  - Laser weeding from 3D imaging



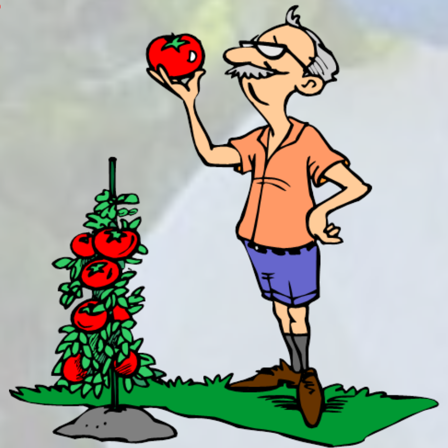

UNIVERSITY OF SOUTHERN DENMARK

Autonomous tractor

GPS to LIDAR steering test

Selective harvesting

- Between 20- 60% of harvested crop is not of saleable quality
- Only harvest that part of the crop which has 100% saleable characteristics
  - Phased harvesting, immediate replacement seeding
- Pre harvest quality and quantity assessment
  - Grading / packing / sorting at the point of harvest
    - Add value to products on-farm
  - Grade for quality
    - Size, sweetness, ripeness, shelf life, protein etc
  - Minimise off farm grading and sorting
  - Add value to on-farm products

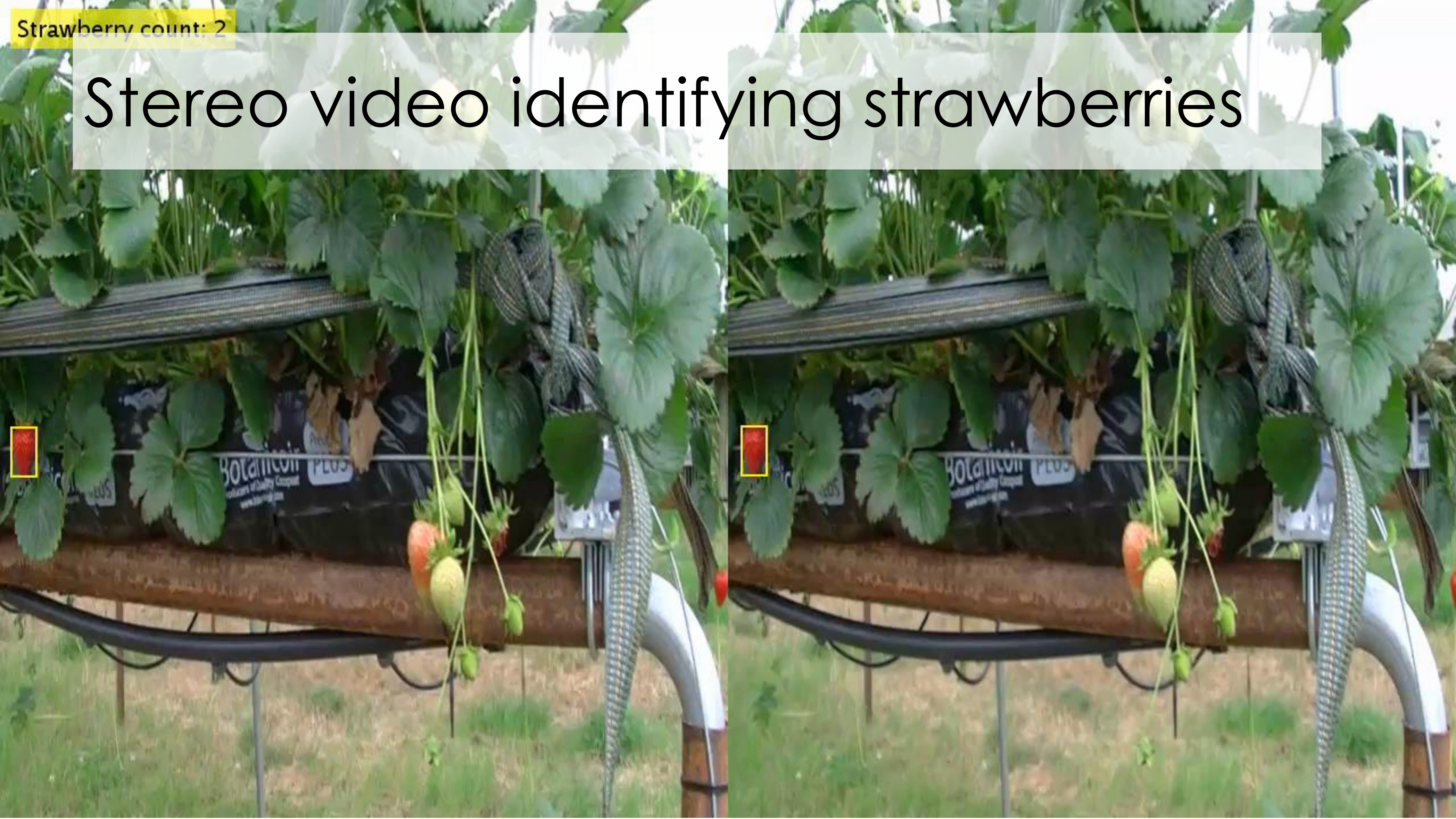



MASSEY FERGUSON
MASSEY FERGUSON

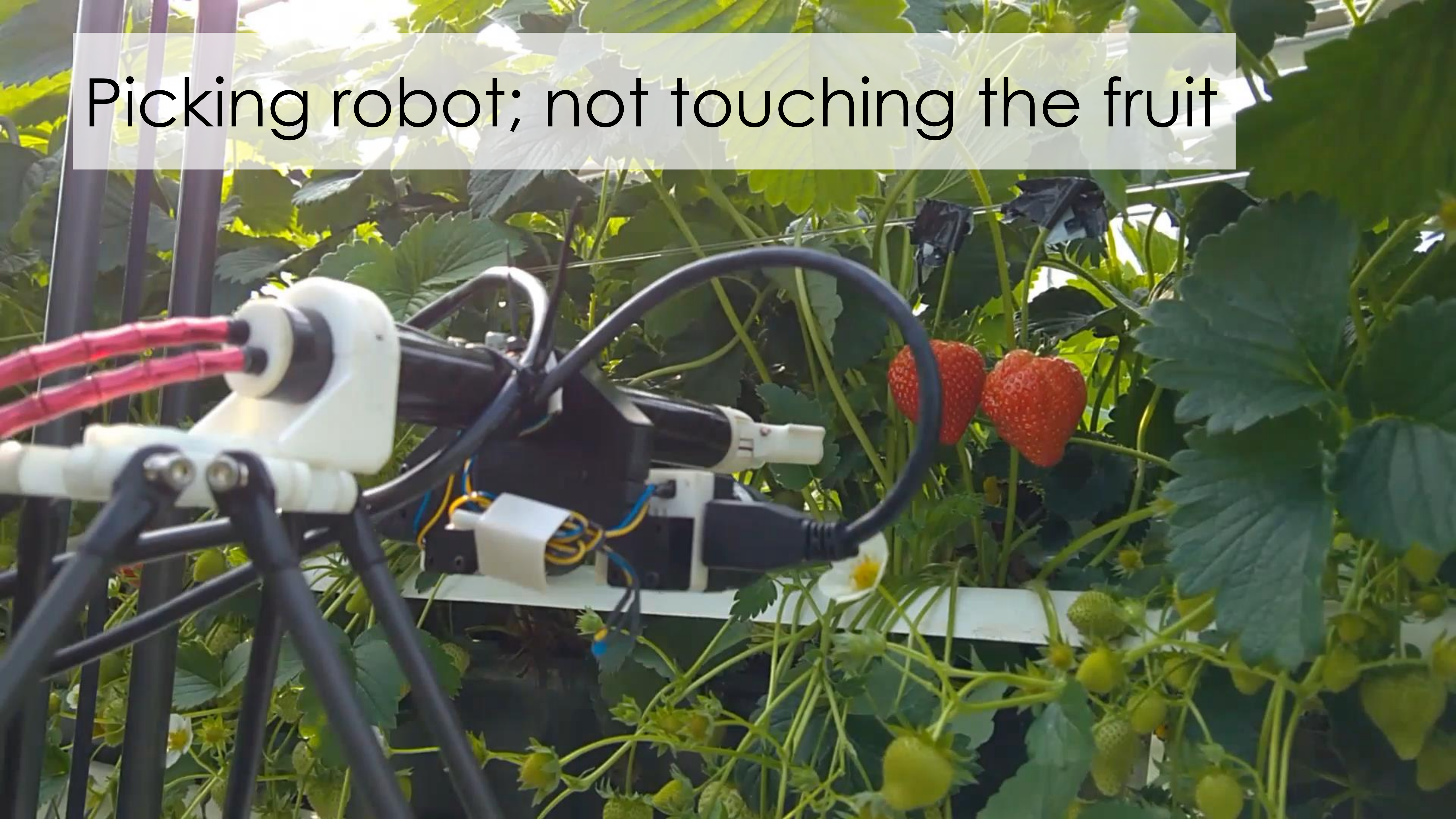
Selective harvesting and grading strawberries

- Stereo RGB vision (Colour and size, 3D position of peduncle)
- NIR for sweetness, shelf life, quality
- Packing at the point of harvest

Stereo video identifying strawberries



Picking robot; not touching the fruit



Hands Free Hectare

- Produce the worlds first automated crop
- Grow one hectare of spring barley without anyone going into the field
- Crop surveyed and sampled by drone
- Soil sampled by robot
- Drilled and sprayed by robotic tractor
- Harvested by robotic combine
  - 3.5t of barley to be made into robotic beer!

Conclusions

- Mobile robots will be used commercially in the horticultural sector first
- Working with two start-up companies looking for vc
- Robots will be very disruptive but will have significant benefits
- Increased yield will come though improving smaller fields
- We are now designing the new systems and trying to understand the implications
- We are always interested in partnerships

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Incorrect assumptions about robotic agriculture

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- Robots are only for big fields
  - Big fields have big equipment that is very efficient.
  - Small fields cannot be currently used with the same efficiency
  - Small robots can increase the efficiency in small fields
- Robots will be too expensive
  - Current big tractors need investment of £100k+ which farmers already pay, plus driver costs
  - Cost of a robot will be about £20-50k and will not need a ‘driver’
- Robots will reduce rural workforce
  - Big tractors have already reduced the rural workforce from what they were 70 years ago.
  - We will still need a farm manager to plan the tasks
  - Still need an agronomist but will be supported by better real-time information
  - The tractor driver will need new skills to become a robot operator.
  - Seasonal labour will be significantly reduced
- Robots will do everything
  - Robots will be used in niche areas like weeding and scouting
  - Large manned tractors will still be needed for road work and heavy logistics
- Robots are not safe
  - New system has seven levels of safety
  - Driverless cars on road, why not tractors?
  - A person is always in charge of the robots via a smartphone.
- Robots are too complex and will need an operator with a PhD
  - With good design a robot should be as easy to use as a smartphone
  - Leapfrog technology
  - Embedded smarts
- Robots are for the future, not now
  - Why not now?

Robots as a service not a product

- Traditional business model
  - Build product and sell it
  - e.g. weedkiller
    - Loss of control after sale
    - Open to misuse
- New business model
  - Sell service with embedded product
  - E.g. eradication of weeds
    - Can use any technology (such as laser weeding)
    - Continual feedback on product and its use
    - Easily updated