How are ground and aerial robotics revolutionising agricultural activities across the globe

Harper Adams University

AGRIEPICENTRE
Engineering • Precision • Innovation

Dr Richard Green
National Centre for Precision Farming
rgreen@harper-adams.ac.uk

www.harper-adams.ac.uk
www.agri-epicentre.com
www.harper-adams.ac.uk/NCPF

National Centre for Precision Farming

National Center for Precision Farming

New £3m Centre

- £1.5m Raised privately
- £1.5m Government (Rt Hon David Cameron (Prime Minister) 2012
- Finished in 2013
  - *"It's great for the UK that Harper Adams is establishing the National Centre for Precision Farming."*
- Liz Truss (The secretary for state for environment, food and rural affairs) Sept 2015
  - *"Shropshire is home to Harper Adams University, the National Centre for Precision Farming, and the Agricultural Engineering Innovation Centre, which is a global centre for excellence in terms of modernising farming techniques."*

Harper Adams University

- Founded 1901 by Thomas Harper Adams
- Crops, Animals, Food, Land and Engineering
- *Circa* 3000 students
- Engineering graduates
  - 98% employment rate in 2016
  - 94% in professional and managerial jobs
  - 2nd place in Field Robot Event 2016
  - University of the Year WhatUni Awards 2016
    - Top for Student Support
    - Top for Job Prospects
- THES Top 50 university in UK 2016

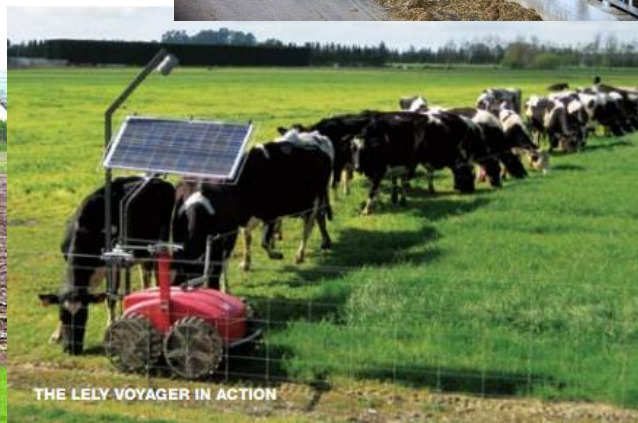
Introduction

- How to achieve long-term sustainability and address current national & global farming and food security issues;
- Reducing chemical wastage via GPS automatic steering systems;
- How to reduce both the cost and environmental impact of food production;
- Using smart robotics to support better decision making in agricultural activities.

Current Agricultural Robots

Harper Adams University

- Milking Robots
- Turf harvesting
- Automatic fences
- Feeding / Pushing / Cleaning



Access to GPS technology resulted in the development of Precision Farming

Precision Farming (Historic View)

Harper Adams University

Precision farming is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. Based on:

- Mapping (Yield, Soil, Moisture, Nutrient, Pest, Disease, etc.)
- Interpretation (Derive prescriptions/treatments based computer analysis of maps)
- Precision Treatment (Cultivations, seeding, fertilizer and pesticide applications)


Yield Sensor
Moisture Monitor
Data
Desktop Computer
Yield Map
Soil Analysis
Prescription Maps
Data Card
Cultivation
Seeding
Fertilisation
Protection
NEW HOLLAND
AGRICULTURE
Tractor + Machine Control
Data Management
Targeted Agronomy

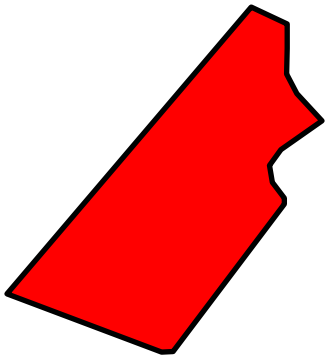
Management units reuction of scale

Harper Adams University

- Conventional or Traditional Farming

  Field

  One rate

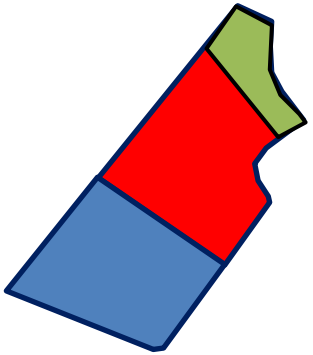


- Variable Rate

  Sub-Field

  Variable dose rate

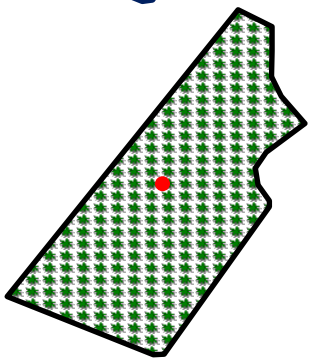
  Patch application



- Single-Plant-Care or Plant Level Husbandry

  Single Plant

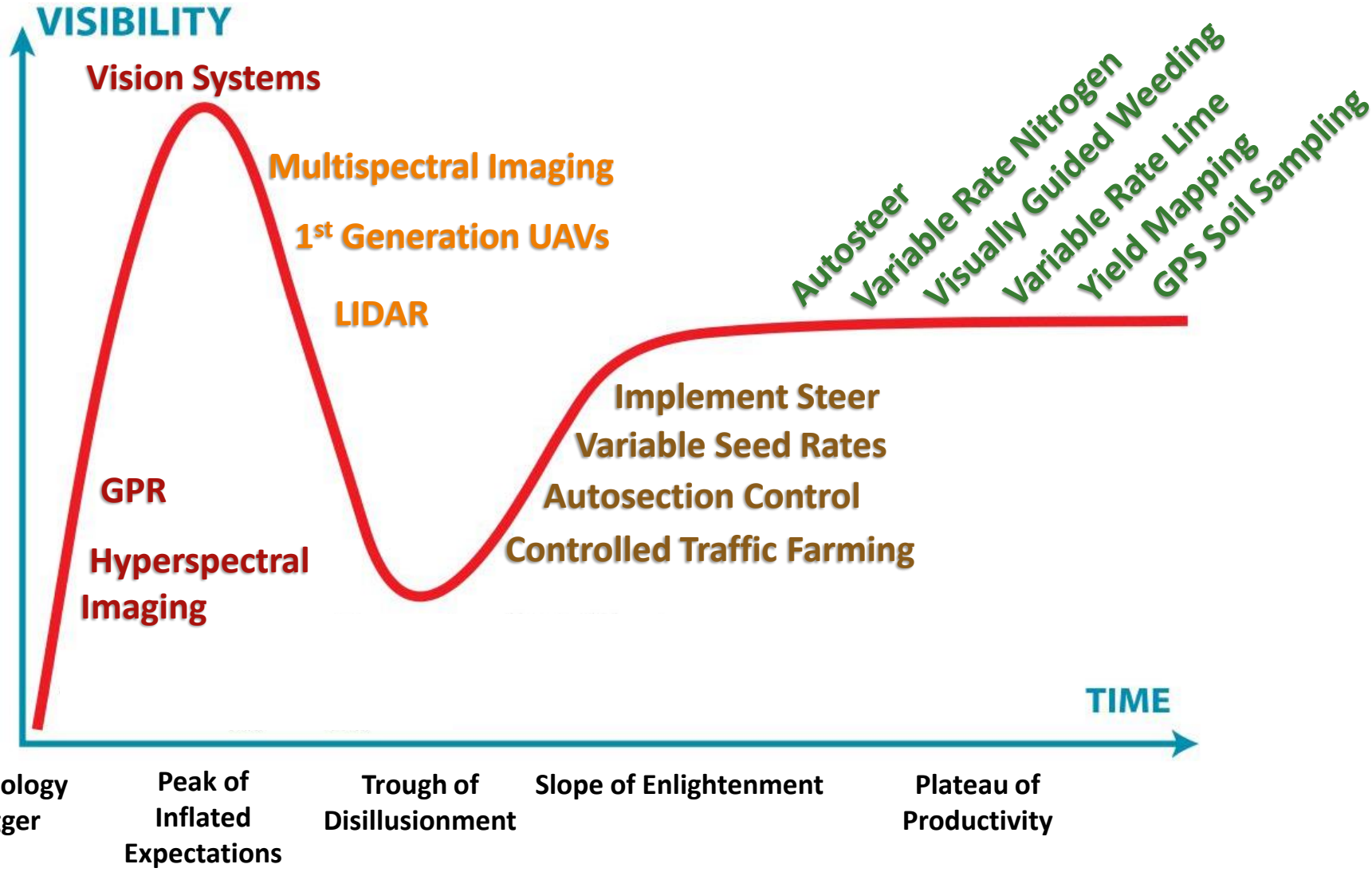
  Individual dose rate



Gartner Hype Cycle

Every new technology passes through these phases

Harper Adams University

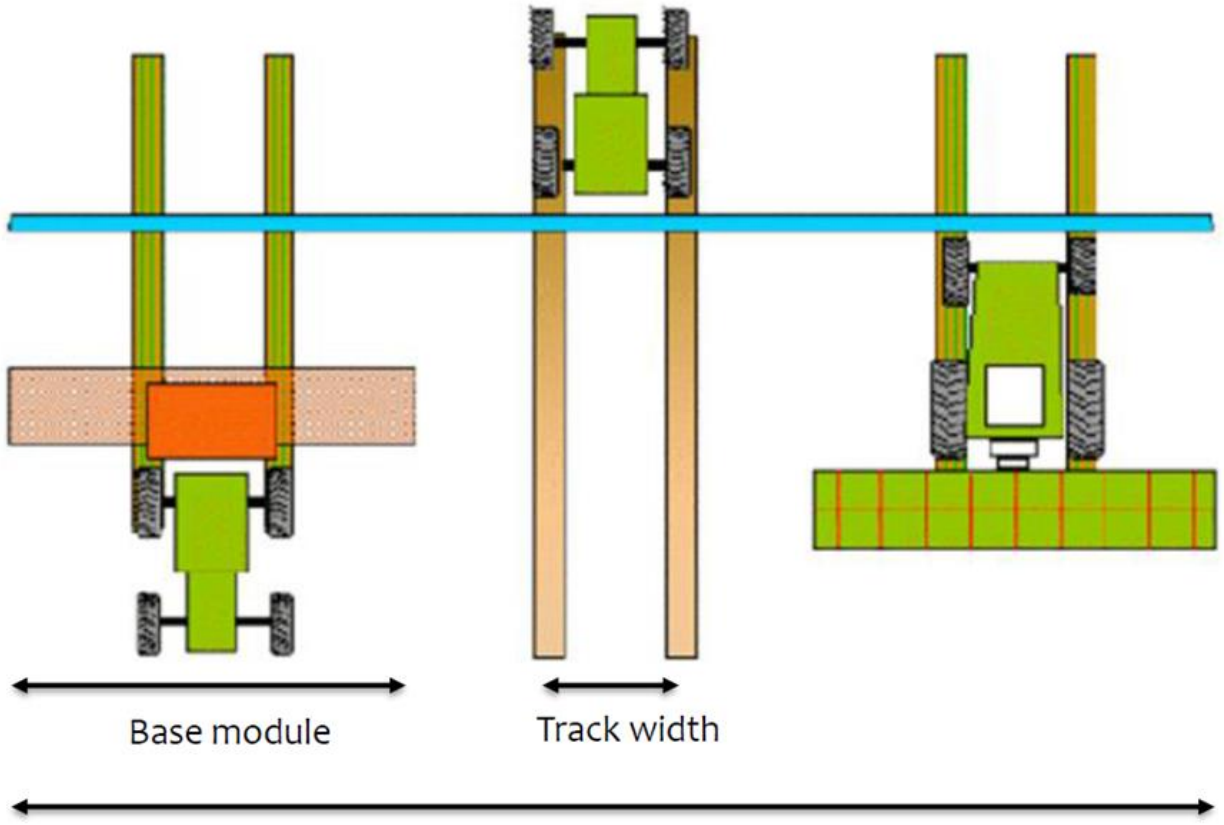


Limitations

- Have relied on historic data
  - "Treating previous years' problems"
- Sample Rate
  - Yield information dependent on machine width
  - Limited number of soil samples/field
  - Image pixel size
- Treatment patch size
  - Dependent on machine working width
  - Treatment technology available
- Lack of scientific information needed to determine prescriptions / treatments
- Computer processing power required

Controlled Traffic Farming

Harper Adams University



- 10 – 20% increase in yield
- 50 – 60% reduction in cultivation costs

Big Bale South

Current State of Ag Robotics & UAVs

Harper Adams University

Commercial agricultural robots and UAVs are being developed for the following applications:

- Tractors;
- Harvesting;
- Smart Implements for Thinning and Weeding;
- Soil Mapping;
- UAS (Drones) for Inspection, Data Collection, Scouting, and Autonomous Patch Spraying.

http://www.therobotreport.com/news/ag-in-transition-from-precision-ag-to-full-autonomy#Clearpath

Robot Tractors

Whilst the technology exists to build fully autonomous robotic field tractors, safety and litigation concerns are deterring the larger manufacturers from selling them. However, they are available from smaller companies who are prepared to adapt tractors for robotic tasks.

Modular tools

Establishment

Micro-tillage
Ultra-high precision seeding
Geocode each seed
Permanent planting positions
Proximity fertilisation
Modular logistics
Reseeding

Harper Adams University

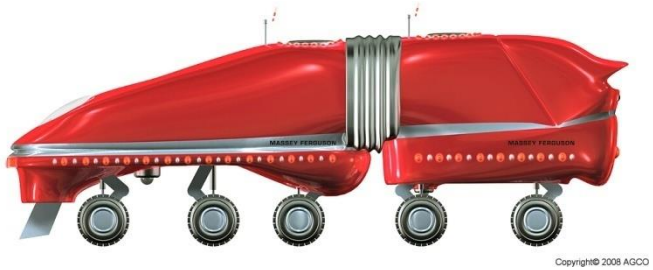
Crop scouting

Non contact / solid state sensors
Biosensors
Luxury data consumption
Inception detection
Repetitive measurements
to improve agronomic decisions

Crop care

Weed recognition
Patch spraying
Micro dots only onto weed leaf
Laser weeding

Selective harvesting

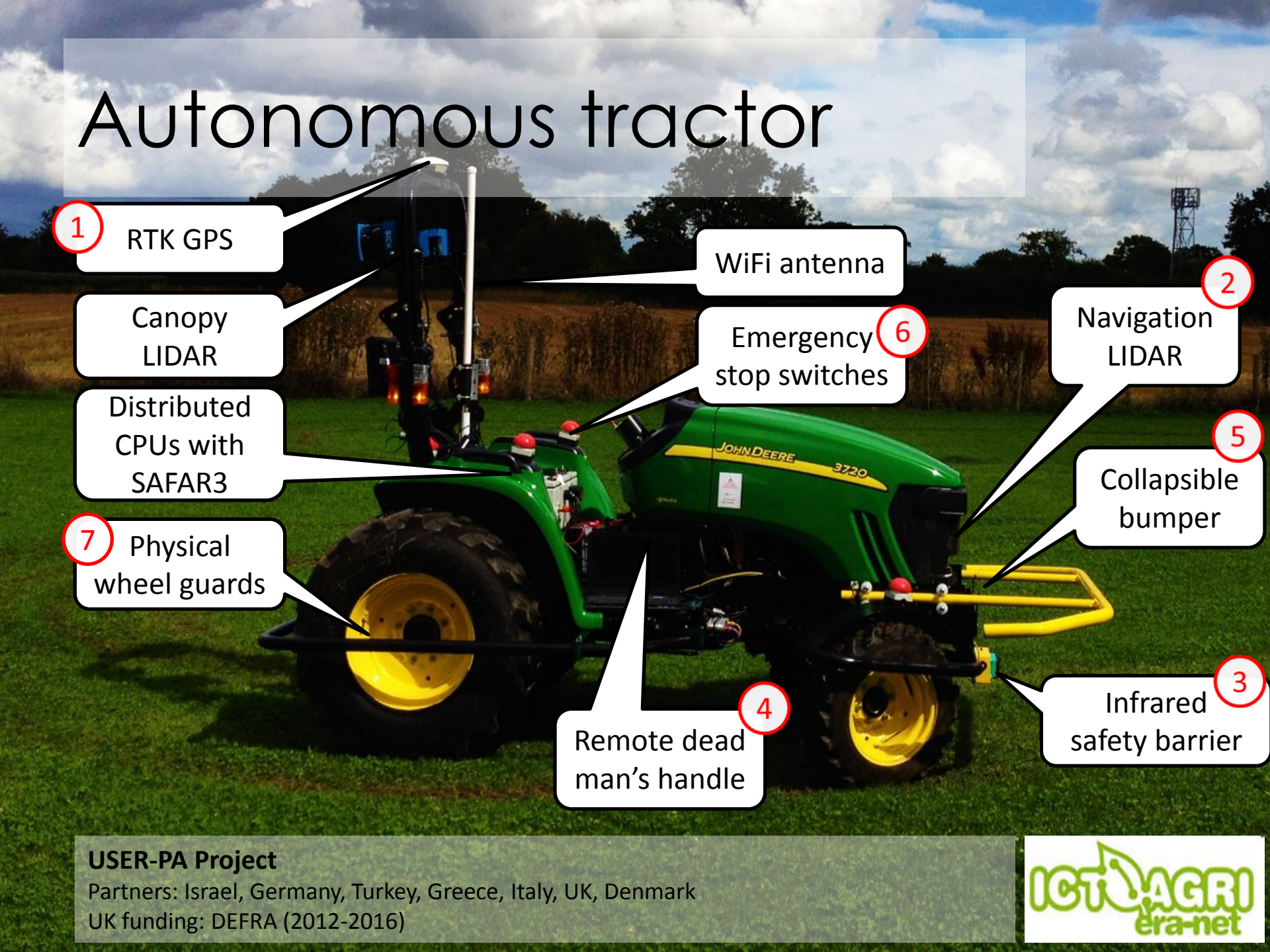


Selective (repeated) harvesting
Intelligent transport & logistics
Phased cropping

Farm Management Information System

National Centre for Precision Farming

Autonomous tractor



USER-PA Project
Partners: Israel, Germany, Turkey, Greece, Italy, UK, Denmark
UK funding: DEFRA (2012-2016)

ICT AGRI era-net

Hands Free Hectare

Harper Adams University

- First proposed by Professor Blackmore as the "The autonomous acre grand challenge"
- Use robots to grow one hectare of a commercial crop in an field that nobody enters
- Only open source software and commercially available equipment will be used
- Funded for 2 years (2016-17)

Robot Harvesters

Commercial companies and universities are developing a range of harvesting robots to pick soft fruit, top fruit, and vegetables. These differ from existing mechanical harvesters as they are designed to minimise damage to the crop, to enable it be sold for top prices. Harvesters generally use one or more arm mounted picking tools, guided to the crop by vision based systems. Crops often have to be specially bred varieties grown in a specific manner that makes the fruit or vegetables more visible and easier to pick. At present these robotic systems are too expensive, slow and unreliable.

Strawberry Harvesting Robot: AUTOPIC

Harper Adams University

- AUTOPIC is a multi disciplinary project aimed at mechanising the harvesting of soft fruit through the use of autonomous vehicles and robotics.
- Partners include Harper Adams University, the Shadow Robot Company, Interface Devices Limited and the National Physical Laboratory.
- Time: 2014 – 2015

National Centre for Precision Farming

Selective harvesting Strawberries; AUTOPIC

- Selective harvester
- Machine vision recognises strawberries in 3D
  - Identifies the peduncle (stalk)
  - Classifies size, ripeness
- Robot arm picks individual strawberries
- Puts it into graded punnet (box) for each quality
- Graded for sweetness, ripeness, shelf life, size etc. according to each supermarket

Stereo strawberry recognition:

Top: Classified by size and colour
Bottom: Peduncle 3D coordinates passed to picking robot

Harper Adams University

2 part and2 non occluded strawberries found

2 part and2 non occluded strawberries found

Strawberry targets

Harper Adams University

Smart Implements for Thinning and Weeding

Harper Adams University

There are a number of tractor trailed or mounted smart implements available for thinning and weeding from manufacturers such as *Vision Robotics*, *Vision Weeding* and *Garford*.

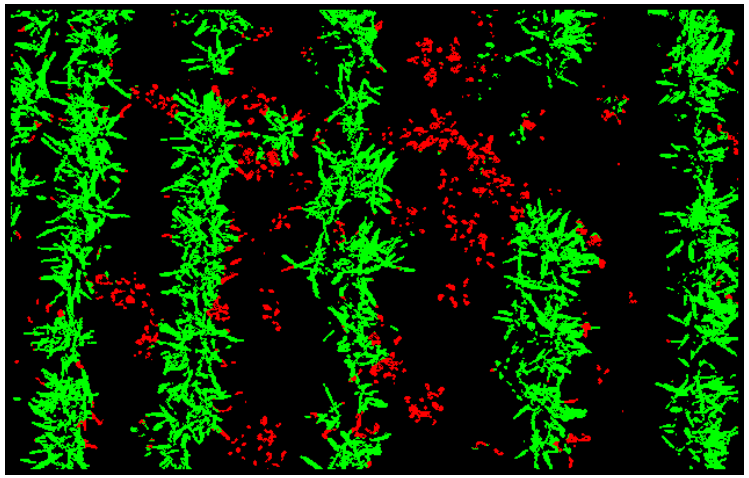
Weed Identification & Removal

Harper Adams University

In arable agriculture image processing is used to identify weeds. Weeds removed by:

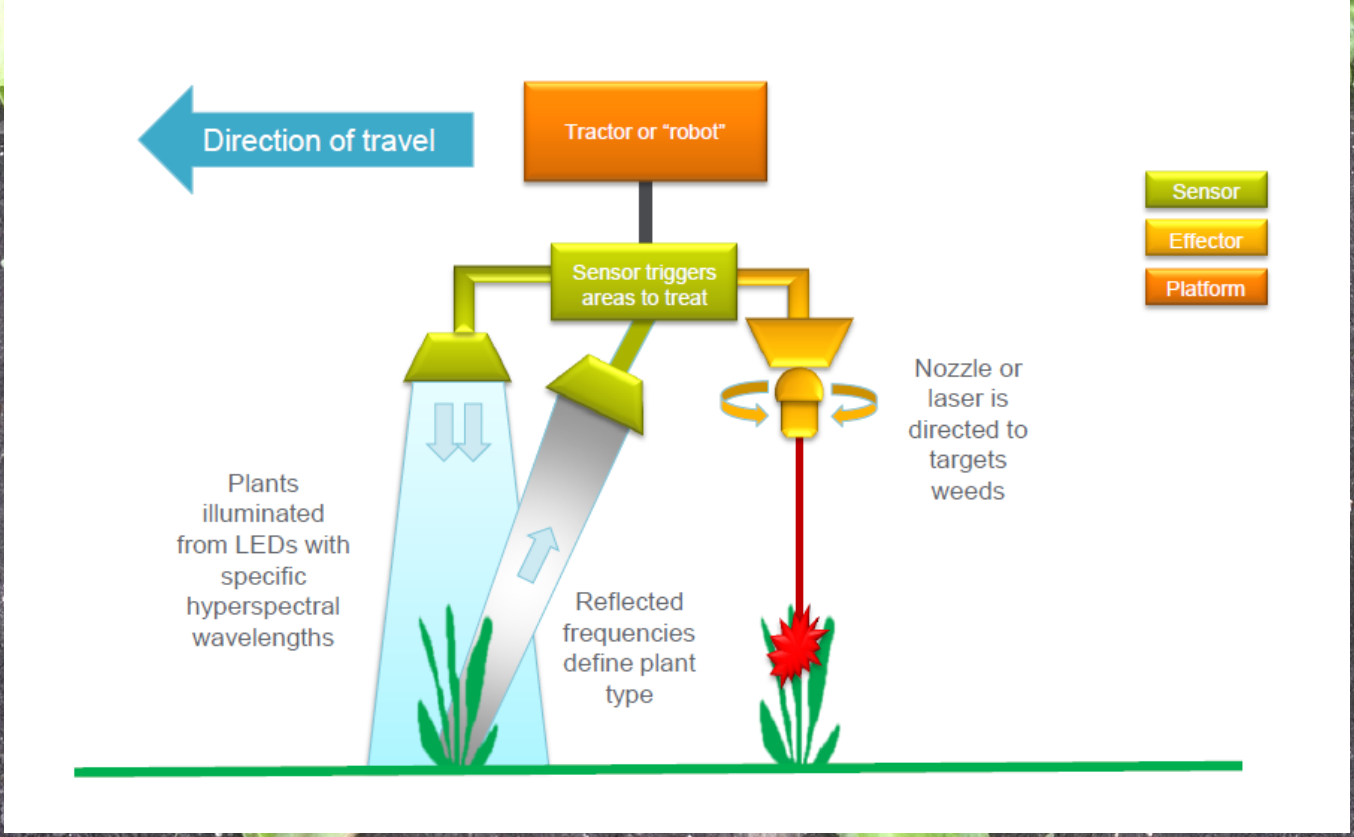
- Inter-row – Robotically steered hoe
- Intra-row – Laser weeding

Original Image



Weed Identification

Crop Care: Laser Weeding



Harper Adams University

MANCHESTER 1824 The University of Manchester

G's Naturally Fresh

BARFOOTS Fresh Thinking

syngenta

Innovate UK Technology Strategy Board

National Centre for Precision Farming

Harper Adams University

Crop & Soil Scouting

Harper Adams University

At present robotic systems do not exist for fully automated soil sampling or crop analysis. There is research taking place around the world to develop robots for soil sampling and crop analysis. Chinese researchers have developed a number of devices that can be pulled through the soil that will measure the NPK values on-the-go without having to send samples away for analysis. These are not available commercially at present.

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

Crop Scouting

Harper Adams University

- 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

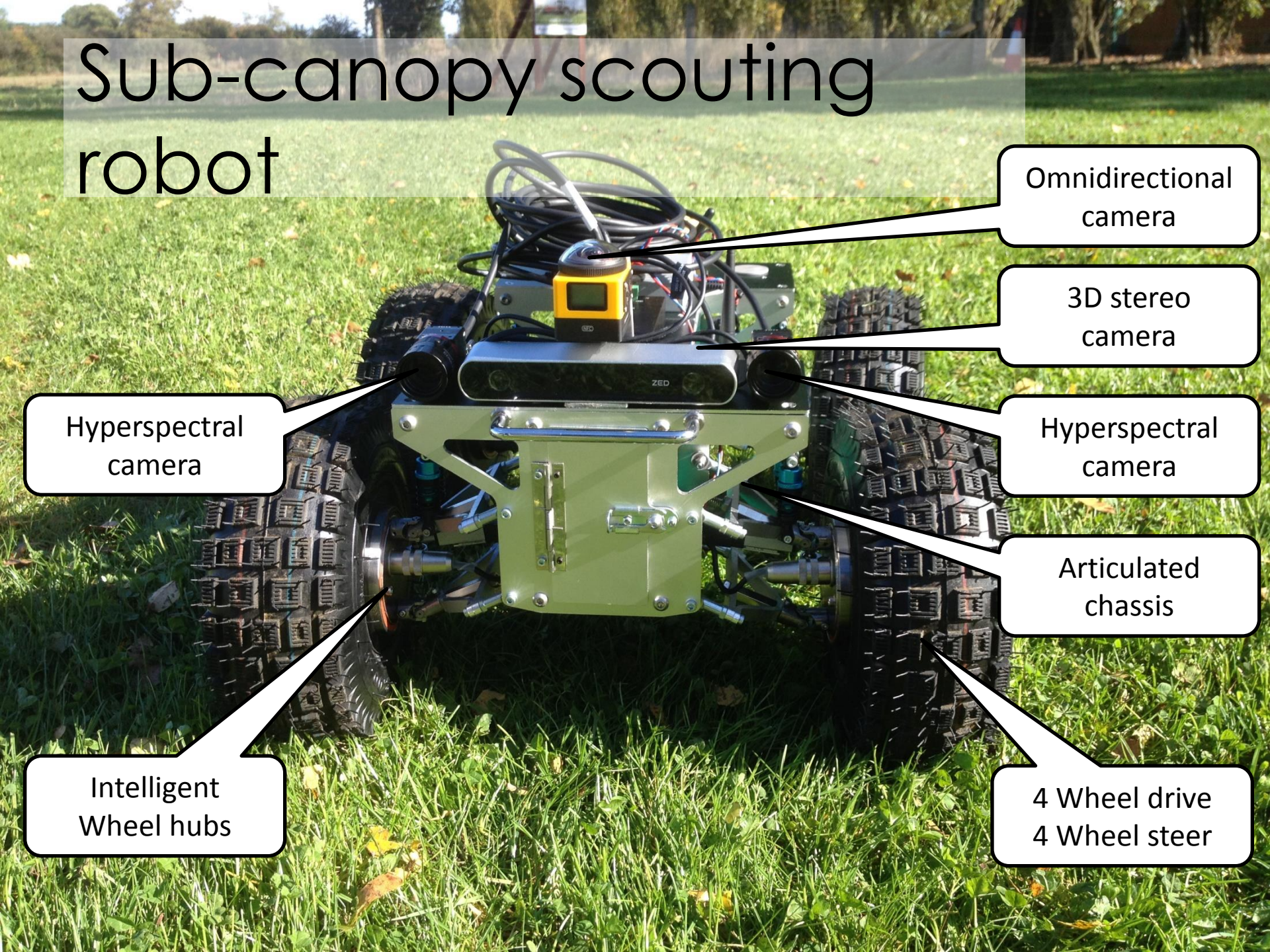
Ricepaddy Project

- STFC Newton fund with China
- Partners
  - Rutherford Appleton Laboratory
    - Harper Adams University
    - NERCITA
- Omnidirectional camera
- 2 Hyperspectral cameras
- Stereo camera
- WiFi
- Operated from smartphone

RAL Space
Autonomous Systems Group

National Centre for Precision Farming

Sub-canopy scouting robot



UAS (Drones) for Inspection & Data Collection

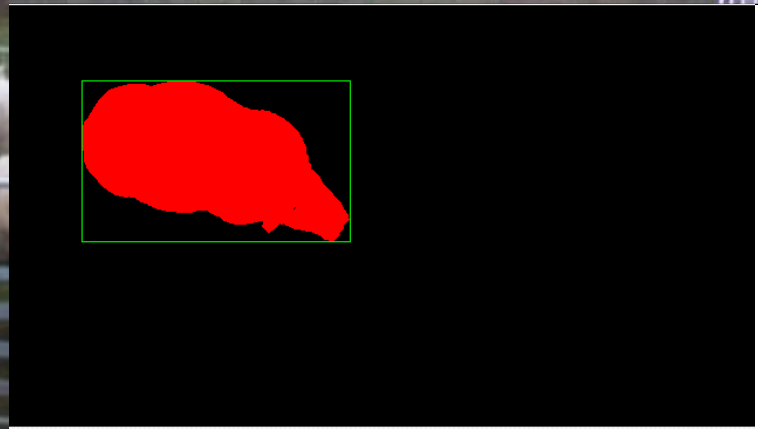
Harper Adams University

Manually controlled drones are currently being used commercially in agriculture for:

- Mapping crops using multispectral cameras;
- Inspecting buildings and checking livestock;
- Spraying (China & Japan)

Identifying Animals by Colour & Size

Harper Adams University



Development of a Sheep Tracking Drone

Harper Adams University

Mustering sheep using a radio controlled quadcopter

Harper Adams University

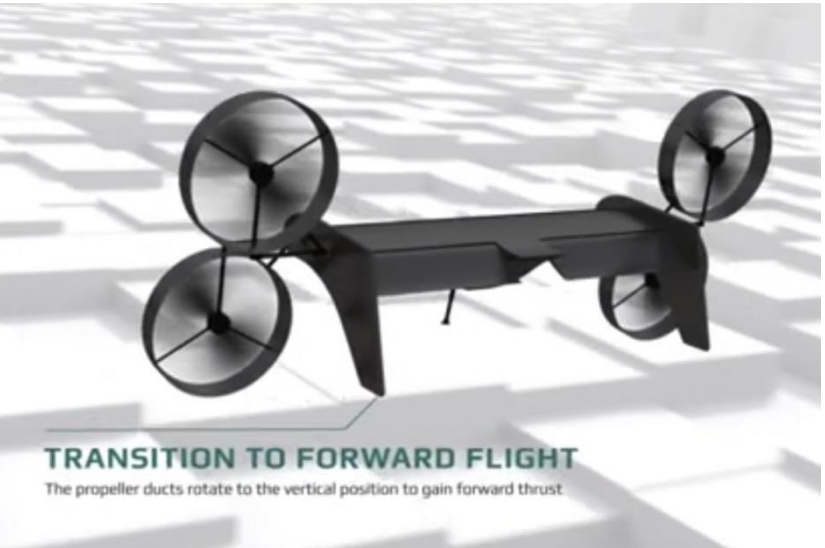
Michael Thomson videos of sheep mustering

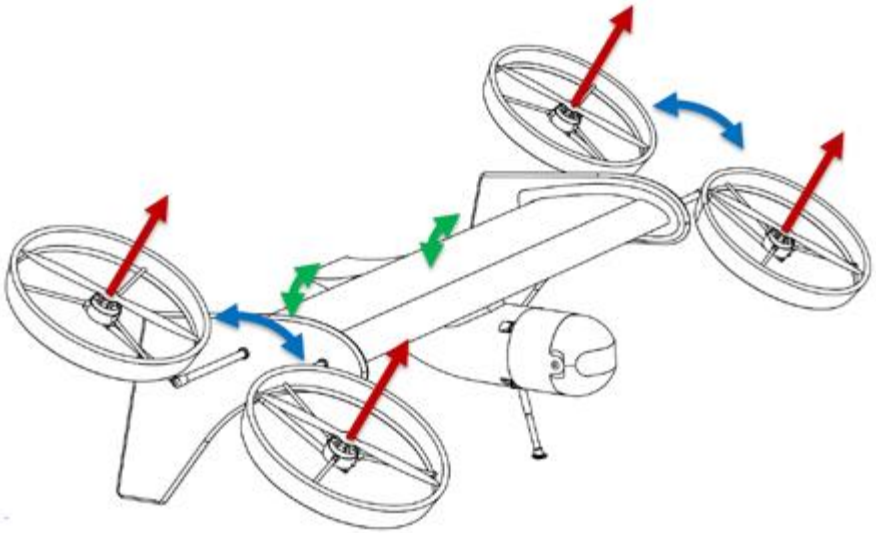
http://www.3news.co.nz/VIDEO-Mustering-sheep-with-a-remote-control-quadcopter/tabid/412/articleID/281606/Default.aspx

VTOL crop sprayer

Harper Adams University

- http://www.vtol-technologies.com/flying-wing.html
- MultiCopters 10 to 20 mins flight time, can hover
- Fixed-Wing Drones 1 to 2 hours flight time, can't hover
- VTOL 50 mins to 1 hour flight time, can hover
- Agri VTOL seeking investors





Agricultural Drone Centre

- Part of the NCPF
- Working with
  - Civil Aviation Authority, RAF, DfT
  - Chemical Regulation Directorate
  - Drone manufacturers
  - Many drone operators
- Spray testing laboratory to accredit drones to spray agrochemicals in the UK

Other Drone Related Research Activities

National Centre for Precision Farming

- Tethered Drones;
- Collaborative co-operation with vehicles;
- Spraying / Micro-treatment;
- Fully-autonomous operation;
- Self docking and refilling;
- Autonomous scouting;
- Improving visibility & Safety systems for drones.

Unmanned Aerial Systems Special Interest Group

Drones for Farming Conference 2016

Thursday 10th November at Harper Adams University

$U 1,550 per person

Launched 6th March 2014
Co-Founders: Harper Adams University and URSULA Agriculture.
Members: BASIS, Agrovista UK, Branston, G2Way, Bayer CropScience, National Aeronautical Centre, PrecisionHawk,
Chris Wray (farmer and NFU Representative).

Membership £250 p.a.
@AgDroning

National Centre for
Precision Farming
AgDroning