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Farming with robots 2050

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FutureFarm

Farming in 2050

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- Identify trends in the past that are true today
- Identify weaknesses in current system
  - Is big always good? Highest yield gives highest profit? …
- Assumptions
  - Desire to have less environmental impact
  - Tighter legislation from EU and UK
  - Energy prices increase
  - More volatile weather due to climate change
  - More competition on world food prices
- UK agriculture must become more flexible and efficient
  - Smarter farming systems supporting smarter farmers


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Current farming system

- Developed for maximum crop production after the war
  - Industrial production line
- Farmers in 2014 face different pressures
  - Changing world prices, Clean Water Directive, volatile weather conditions, Single Payment Scheme, ….
  - Farmers are moving towards "Flexible Manufacturing" techniques

The Royal Veterinary and Agricultural University

Intra-row Weeding with a Cycloid Hoe

Denmark, May 2006

Current system: Size

- Mechanisation getting bigger all the time
  - Due to driver costs
    - Doubling work rates keeps costs down
  - Reaching maximum size
    - Combines are now at maximum size that can fit inside a railway tunnel for transport
    - Good for large fields
  - Small working window needs a bigger machine but the bigger the machine the smaller the working window.
    - Self fulfilling prophecy
    - Horsepower does not help when weight is the problem
  - We cannot change the weather but we can change the tractor


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Current system: Compaction

- Up to 90% of the energy going in to cultivation is there to repair the damage caused by machines
  - If we do not damage the soil in the first place, we do not need to repair it
    - "Recreational tillage", "Do not treat soil like dirt"
  - "The best thing to do with soil is leave it alone"
    - The best soil structure can usually be found in forests
    - Natural soil flora and fauna condition the soil structure

Current system: Trafficking

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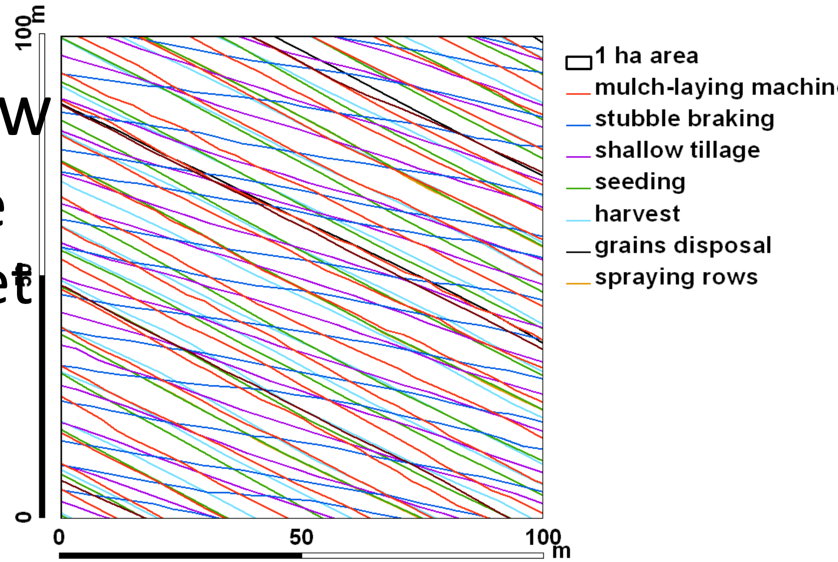
- Up to 96% of the field compacted by tyres in "random traffic" systems
- Spatial control of machinery can save:
  - 10-15% time, fuel and inputs
  - Complete optimised route planning
  - Controlled Traffic Farming
- Expand the working window
  - Lighter low ground pressure vehicles that can work in wet weather conditions and not damage the soil



Optimised route planning

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Current system: Design

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- Tractors designed to pull large horizontal draught loads
  - Big wheels at back for larger contact patch
  - Cleats on tyres to help dig through mud
  - Weights on front for weight transfer
  - Every 1 kN draught force needs 1 kN vertical force
    - Weight causes soil compaction
- Cab for driver
- Many farms have smaller numbers of large tractors
  - Many operations are now over powered and waste energy as the tractor is not matched to the implement

New opportunities: ICT

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- Wireless communications
  - (WiFi, 3G, 4G, Zigbee, 24GHz)
- CPU doubling every 18 months (Moore's Law)
- Non contact solid state sensors
  - Phenotyping outdoor crops
- New sensors and techniques for agriculture
  - (NDVI, NIR, EMI, Red edge inflection, ground penetrating radar, terahertz, Chlorophyll florescence, Light curtain, laser scanning, ….)
- Automation leading to robotics
  - SAFAR (Software Architecture for Agricultural Robots)

New Opportunities: Workforce

- "Computers and robots will take people's jobs"
  - "I think there is a world market for maybe five computers" Attrib. T.J.Watson (CEO IBM 1943)
  - 1,966,514,816 computers connected to the internet in 2010
- While agricultural robots will replace semi-skilled drivers, an equal number of highly skilled agricultural robot engineers will be needed

Robotic agriculture

- Keeping seeds, sprays, fertiliser etc. the same
- Remove machine constraints
- Focus on plant needs
- Farm Management Information System
- Four stages
  - Crop establishment
  - Crop scouting
  - Crop care
  - Selective harvesting

Crop establishment

- Micro tillage
  - Why cultivate the whole topsoil?
- Non draught force
  - Use vertical or rotary methods
- Permanent planting positions
  - Same place each year
- Seeding depth to moisture
  - Improve germination rates

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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 NCPF seminar 30th Jan)
  - 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

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Selective harvesting

- Up to 60% of harvested crop is not of saleable quality
- Only harvest that part of the crop which has 100% saleable characteristics
  - Phased harvesting
- 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
- Extend traceability from farm gate back to individual treatments (meta data)


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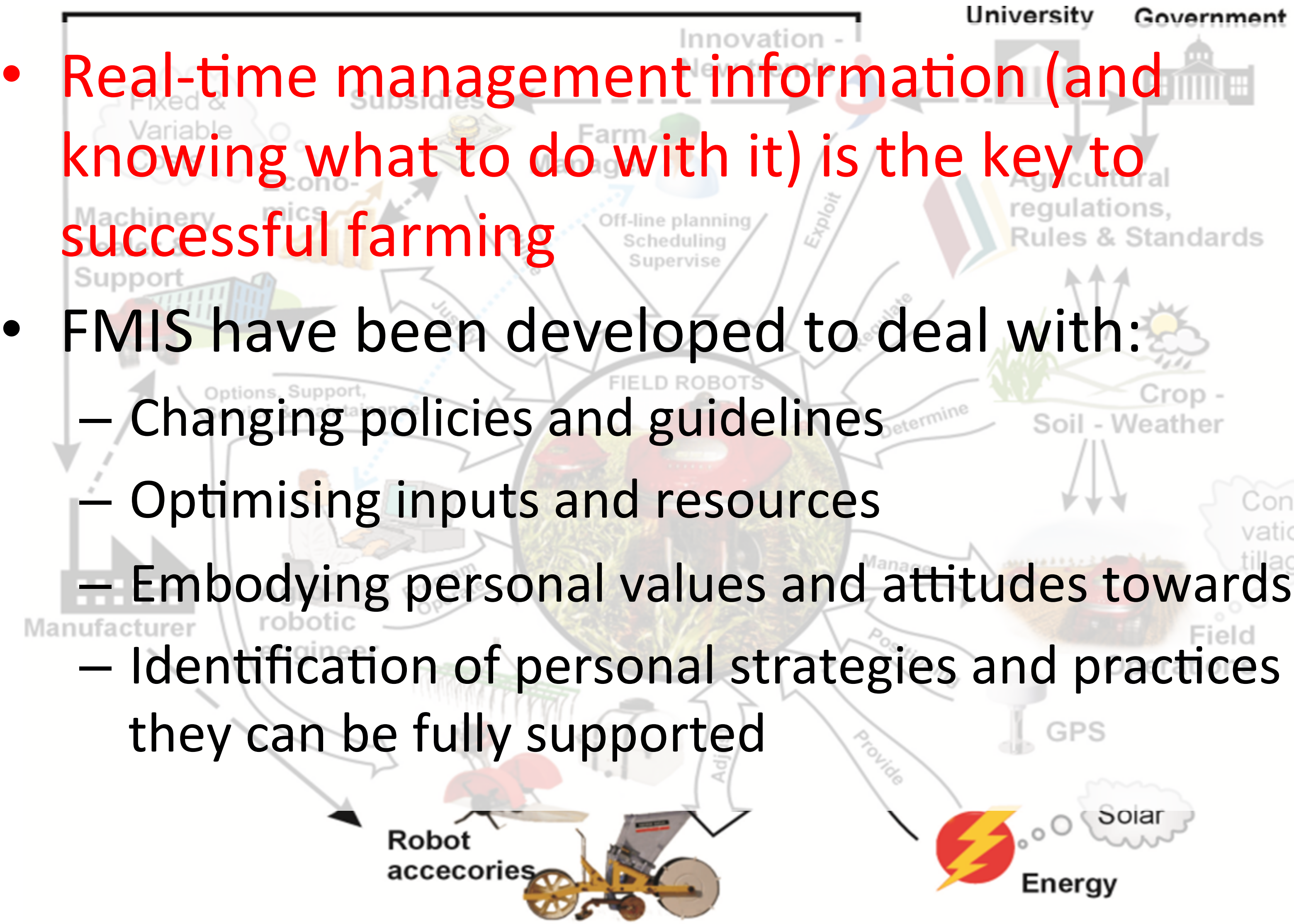
FMIS / RMIS

- Real-time management information (and knowing what to do with it) is the key to successful farming
- FMIS have been developed to deal with:
  - Changing policies and guidelines
  - Optimising inputs and resources
  - Embodying personal values and attitudes towards risk
  - Identification of personal strategies and practices so they can be fully supported



Large tractors

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- Some operations will still need large manned machines
  - Harvesting large crops
    - 40 t/ha potatoes
    - 70 t/ha sugar beet
- Agricultural machines will be a lot smarter than they are now
- Implement controls the tractor through the ISOBUS

Big data

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- Concept just starting to be applied to agriculture
- Data previously not used can be stored and analysed
  - Yield maps over many years
  - Market prices and macro trends
  - CAN bus data from modern tractors
- Manufacturers analyse real-time data to advise on potential problems and understand usage

Conclusions

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- Is this the future for 2050 or now?
- All of these concepts have been developed and initially researched
- Not many of them are commercially available through "lack of demand"
- How long will it take for UK farmers to take advantage of these new opportunities?

MicroDot spraying

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- Machine vision recognises the leaves of the plant in real time and records the position and speed
- MicroDot sprayer puts chemical only on the leaf of the plant saving 99.99% by volume

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Laser weeding

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- Machine vision recognises the growing point of the weed
- Laser kills the weed by heating the growing point
- Saving 100% herbicide

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- Harper Adams University is now building a real-time robot to laser and microdot weeds
- Funded by a major agrochemical company 2014-2017

Dionysus robot

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- Crop scouting robot for vineyards
- Build by Harper Adams MEng (2013) 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

Robotti

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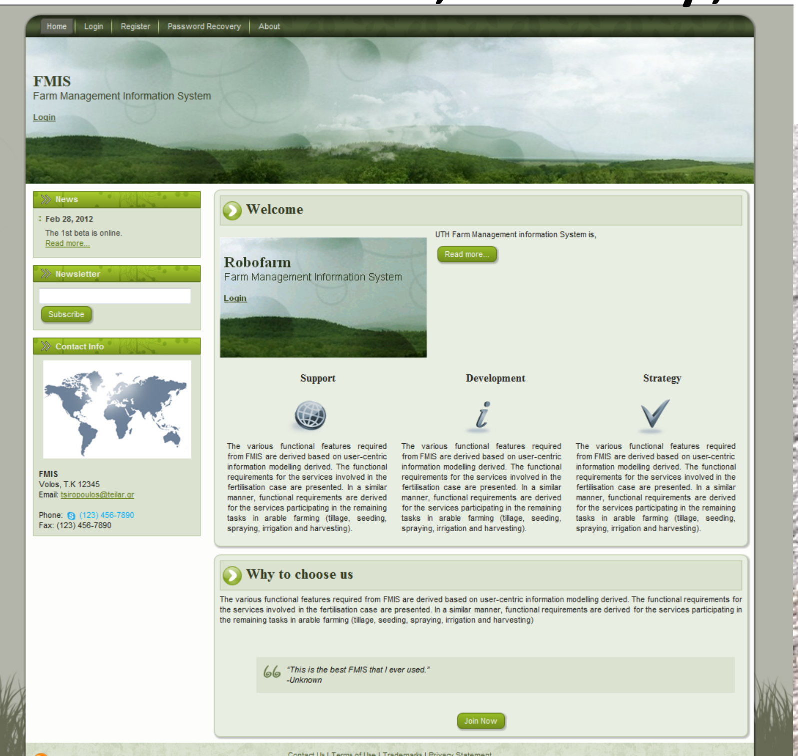
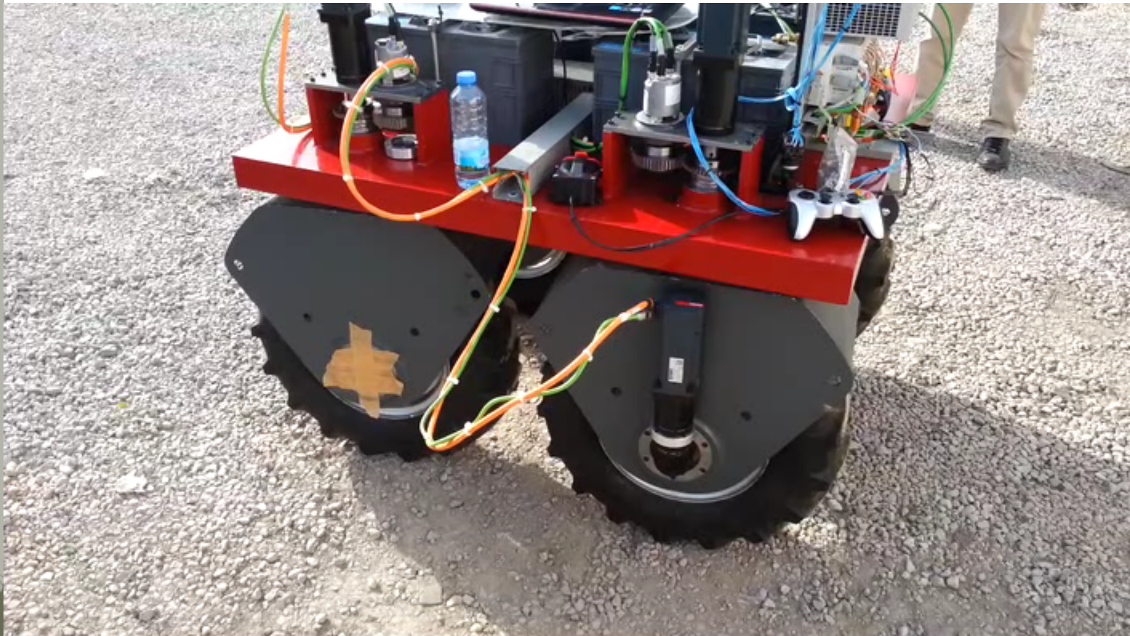
RoboFarm

- Integrate FMIS and robotics
- ICT-AGRI ERA-NET project 2012-2014
- Greece, Turkey, Italy and UK





Project: User-PA

- Usability of Environmentally sound and Reliable techniques in Precision Agriculture
  - How to make PA and robotics easier to use
- Build, test and demonstrate;
  - Orchard sensing robot
  - Vineyard sensing robot
  - Robot Management Information System
- ICT-AGRI (ERA-NET) European network
- Israel, Germany, Turkey, Greece, Italy, UK, Denmark
- €1m (2012-2016)