Developing the Industry Ready Graduate

Greg Rowsell
Dean of Engineering
Mission Statement

“Higher education and research for the delivery of a sustainable food chain and rural economy”

Academic Departments:

– Animal Production, Welfare & Veterinary Sciences
– Crop and Environment Sciences
– Engineering
– Food Science & Agri-Food Supply Chain Management
– Land, Farm and Agribusiness Management
Harper Adams University

- Founded in 1901
- Commercial farm, inc
  - >1300 acres arable
  - 400-cow dairy unit
- Regional Food Academy
- Anaerobic Digester
Recent Highlights

• 96% Graduate Employability (HESA 2014)
• 100% Research Internationally Recognised (REF 2014)
Engineering Department

Undergraduate (MEng, BEng, BSc)
– Mechanical Engineering
– Agricultural Engineering
– Automotive Engineering (Off-Highway)

Postgraduate
– MSc Applied Mechatronic Engineering
– MSc Precision Farming
– MRes, MPhil, PhD

Agricultural Engineering Innovation Centre
Industrial partners
Graduates Skills Gap

The Institution of Engineering and Technology
Report on UK Graduates:

“Graduates’ main shortfalls are their lack of practical experience, leadership skills and technical expertise”
HAU Graduate Demand

Placement

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<th>Subject Areas</th>
<th>HAU Engineering</th>
<th>UK All Eng &amp; Tech</th>
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Graduate

- 98% Harper Adams University Engineering
- 91% All UK Engineering and Technology

“The Industry recognises Harper Adams as a Centre of Excellence”

Richard Nankervis, Project Manager, JCB
ADDRESSING THE NEEDS AND CHALLENGES FOR INNOVATION IN AGRICULTURAL CURRICULA

Agricultural Higher Education in the 21st Century
Global challenge to meet world demands for food security and sustainability
Current farming system

- Developed for maximum crop production after the war
- Analogous to an Industrial Production Line

(Very Brief) history of the Industrial Production Line

i. Before the Production Line
   Localised activity - too much variability and small volume

ii. Production Line (Henry Ford)
    Process flow (increased volume) but no variety

iii. Competitors
    Variety but no flow (increased waste)
Car Industry success

Application of *Lean Thinking*:
- The identification of **value** *(voice of customer)*
- The elimination of **waste** *(e.g. over production, defects, transport)*
- The generation of **flow** *(of value to the customer)*
Process Synergy...

INPUT
Raw Materials → CHALLENGE
Increase Output/Quality; Reduce Costs → OUTPUT
Car

INPUT
Seed → CHALLENGE
Increase Output/Quality; Reduce Costs → OUTPUT
Food

INPUT
School Leaver → CHALLENGE
Increase Output/Quality; Reduce Costs → OUTPUT
Industry Ready Graduate
Innovation

1. A new idea, or more effective process.
2. Can be viewed as the application of better solutions that meet new requirements, inarticulated needs, or existing market needs.
ADDRESSING THE **NEEDS AND CHALLENGES FOR INNOVATION** IN AGRICULTURAL CURRICULA

Sources of Innovation
Robotics engineer *Joseph F. Engelberger* – innovation only requires:

1. A recognized **need**;
2. Competent people with relevant technology;
3. Financial support.
• We want our graduates to be innovative – so this shows us that a key graduate skill is:
  – Ability to identify the Customer Requirements (VOC) and define the problem...the NEED

• Lets start to tie together the customer NEED and hence the technological competences that will be required of graduates...
Farming in the future

Farmers will increasingly face different pressures:
- Sustainable food supply in changing conditions
- Improve farm economic viability
- Desire to have less environmental impact
- Tighter legislation from EU and UK
- Increase in Energy prices
- More volatile weather due to climate change
- More competition from world food prices

PROPOSAL

Global Food Security for 2050 can be addressed by the Application of Lean Philosophy (learnt from the car industry) to Arable Production Systems

Produce MORE with LESS (Energy, Resources)(Waste)
Farming with robots

PRINCIPLES
- Keeping seeds, sprays, fertiliser etc. the same
- Remove machine constraints
- Focus on plant needs
- Farm Management Information System

Process - Four main stages
- Crop establishment
- Crop scouting
- Crop care
- Selective harvesting
But first….Compaction

• Mechanisation: machines getting bigger all the time
  – Due to:
    • Driver costs - doubling work rates keeps costs down
    • Every 1 kN draught force needs 1 kN vertical force
      – Weight causes soil compaction
  – Small working time window needs a bigger machine but
    the bigger the machine the smaller the working time
    window.
    • Self fulfilling prophecy
    • Horsepower does not help when weight is the problem
  – We cannot change the weather but we can change the
    tractor
Current system: Compaction

- Up to 90% of the energy going in to cultivation is there to repair the damage caused by large machines.
- Up to 96% of the field area compacted by tyres in "random traffic" systems.
- If we do not damage the soil in the first place, we do not need to repair it.
- Move towards Controlled Traffic Farming.
Route Planning
Crop Establishment: 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 Establishment: Robotic Seeder

• Micro tillage and pesticide
  – Can we only cultivate for each individual seed position?
• Exact known planting positions
  – Anything else is a weed
Synchronised planting
Orthogonal interrow mechanical weeding (Organic farming)
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
UGV Development

Dionysus
• Crop scouting robot for vineyards
• Developed by Harper Adams MEng students for the University of Athens
• Thermal camera for irrigation status
• Multispectral camera for nutrient status
• LIDAR for canopy extent and density

User-PA
• Orchard Sensing Robot
• Robot Management Information System
Crop Care

Organic-Mechanical weeding

- Very expensive (£1000/hectare)
- Needs to be repeated x 3
- Infestation = whole crops are wasted
Automatic row detection
Weed detection
Microspraying

- Seed map gives initial guidance points
- Recognise weeds in close-to-crop area
- Microspray only the weeds
Laser weeding

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

- Harper Adams University is developing a real-time robot to laser and microdot weeds
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
  - Add value to on-farm products
Robotic Agriculture

By applying Lean Production thinking:

• Minimize energy & resources going in to crop production
  – Intelligently targeted inputs saving up to 99% of inputs or 100% of chemical weedkiller
  – Relies on data to define requirements (NEED)

• Minimise soil damage & compaction
  – Smaller, smarter, lighter machines
  – Less soil damage, bigger trafficability windows
  – Multiple machines to increase work rates

Precision Farming = Smart Farming
  – Re-invent mechanisation system with small smart machines that can care for individual plants
Curricular Requirements

DRIVEN BY NEEDS OF CUSTOMER

We have just identified a NEED for graduates who will be increasingly capable in:

– Machine vision / pattern recognition

– Systems integration
  • Sensor technology
  • Communication protocols
  • Power management

– Machine intelligence;

– Programming
But actually:

– Technology is developing at an ever increasing pace
– Students starting in 2017 won’t graduate until 2021 at the earliest...
– Will therefore only have 9 years to make an impact (hence the NEED for Industry Ready)
– And then need to be able to remain ‘useful’ for another 50+ years...
Curricular Requirements

DRIVEN BY NEEDS OF CUSTOMER

So let me propose that the real NEED is:

Behavioural

• *Capability* to identify customer need and project manage
• *Capability* to find, evaluate and synthesise information
• *Capability* in the underlying core fundamental principles
  – Technical
  – ‘Lean’ thinking
What is Capability?

Industry is our customer, not the student.

We must teach what industry needs/not just what we know or are comfortable with.
What is Capability?

Commonly held belief that students should own their learning.

Student learning is our responsibility: just because we’ve said it, doesn’t mean they are capable in it.
Definition of Capability

“It is often believed that the ability to apply knowledge infers capability...”
Definition of Capability

- Awareness (1)
- Understanding (2)
- Application (3)
- Analysis (4)
- Evaluating (5)
- Creating (6)

Application of Knowledge

- Knowledge (1)
- Apply to a discipline (2)
- Apply across disciplines (3)
- Apply to predictable applications (4)
- Apply to unpredictable applications (5)
• The potential for:
  – Lean Thinking to address global food security
  – & The capability model to ensure Industry Ready Graduates

  can be demonstrated by...
2014
FARMING by SATELLITE

2nd prize ...

James Meadows, James Chapman
Miles Metcalfe, Glen Ebsary
Harper Adams University, UK

Demeter - Autonomous
Precision Seed Planting Robot
2013 Farming by Satellite

Winner & Runner-Up
Student Project
Applying Lean to Reduce Down-time

• Case Study:
  – 2014 Potato Harvest
    (Grimme Tectron 415 Potato Harvester)

• Outcome:
  – Application of *Lean Methodologies* could save:
    376.2 hours of Downtime
    & £22839.00 repair costs
Student Project
Optimising an Onion Grading Facility

Layout before improvement process

Layout after improvement process
Student Project
Optimising an Onion Grading Facility

Resultant benefits

- Supervisor Availability
  - 3.7% available
  - 92.2% available

- Debris trailer Operations/shift
  - 10
  - 4

- Supervisor Motion/shift
  - 22434m
  - 15515m

- Processing time
  - 32 shifts
  - 25 shifts