The Institution of Engineering and Technology

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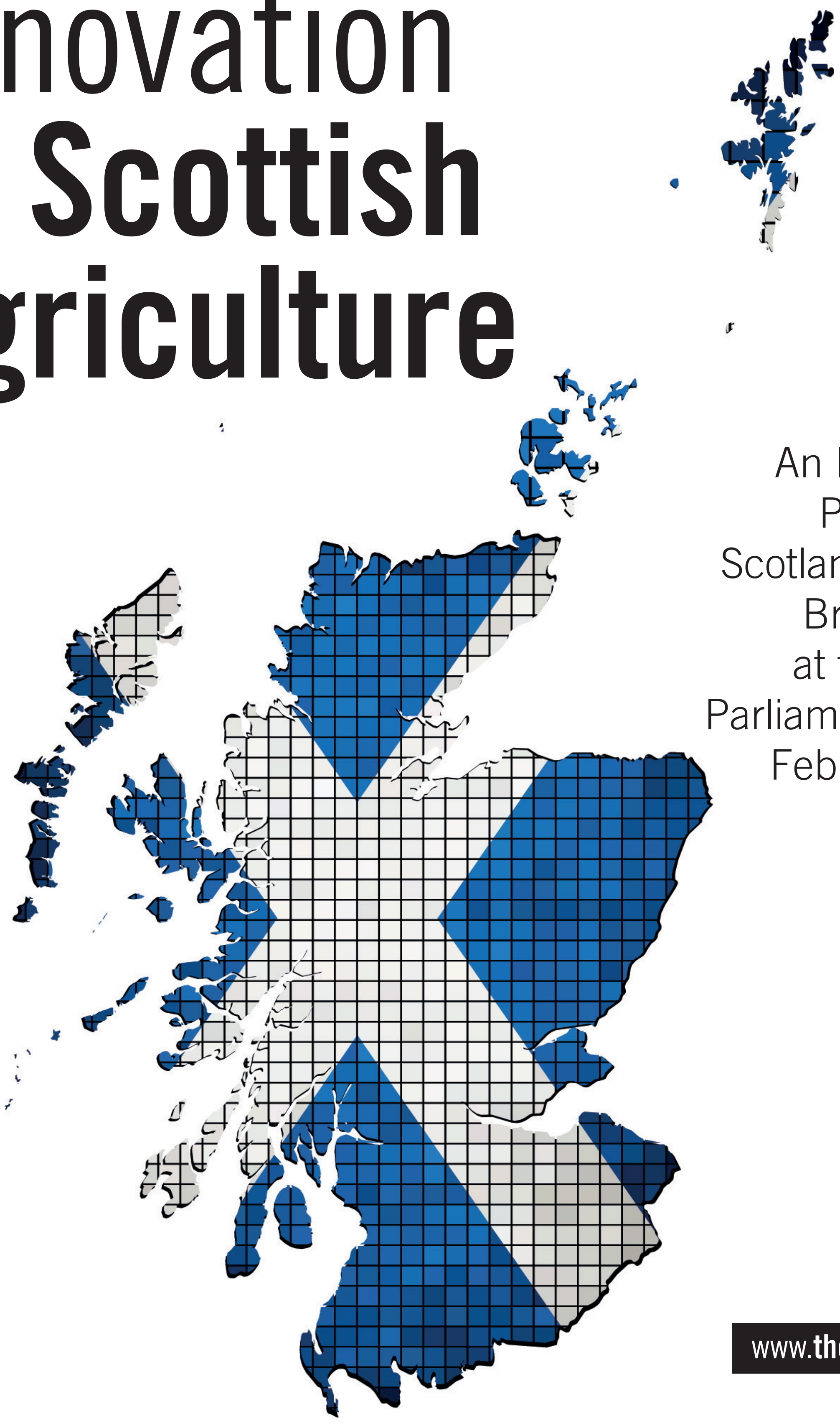
Innovation in **Scottish agriculture**



An Engineering Policy Group Scotland Holyrood Briefing given at the Scottish Parliament on 18th February 2018.

The Internet of Agricultural Things

On 27 February 2018, the Engineering Policy Group Scotland held a briefing at Holyrood Briefing, hosted by Edward Mountain MSP. The audience which comprised a mix of parliamentarians, industry professional and academics heard from speakers based in the University of Strathclyde, the Centre of Agricultural Innovation in Precision Farming (AGRI-EPI) and Harbro. In addition to the engineering developments in agriculture, the importance of broadband connectivity and the advantages which 5G coverage will bring to rural areas were also stressed.

Eight MSPs who attended this event were presented with practical examples of this new technology. Questions afterwards highlighted matters such as the necessity of promoting agricultural productivity in post Brexit Britain when the numbers of casual agricultural workers from Eastern Europe may be in decline. Although some expressed concern about the future of the Common Agricultural Policy, it was pointed out that a subsidy regime is not always conducive to innovation.

70% of the UK's area is utilised for agricultural production and the agri-food sector contributes to over £109B to the UK GVA. A crucial component is the primary production element of the supply chain which also supports remote and fragile rural economies. The sector is experiencing an increasing drive towards efficiency and performance enhancement to improve sustainability against a backdrop of increasing global food requirements in the next 10 years and the volatile trading environments that may emerge as a consequence of Brexit.

As a consequence of fundamental drives, agri-technology deployments are accelerating; indeed, the UK based supply chain includes a number of internationally competitive agri-tech businesses that sell overseas as well as the domestic market e.g. agri--tech contributed £14.3B to UK economy in 2013. Three key areas are identified as; the **autonomous systems** market, predicted to undergo spectacular growth globally in the agri-sector alone. GAGRs are quoted in the range 40-60%, with predictions up to £78Bp.a. by 2025 from £3B; (2) **remote monitoring of cropping** assets, using aerial imagery e.g. UAVs/drones. Similar high growth predictions are envisaged where agricultural applications/services are a large segment of a global market of $17.82B in 2017, predicted up to $48.88B by 2023, at an estimated CAGR of 18.32%; (3) **precision livestock farming**. The UK dairy sector is worth £4.7B, and the beef and sheep sectors, £3.7B. Precision sensor technology is a fast growing market for this sector, an ideal opportunity for UK based SMEs to increase revenues in the next 5 years. Products are at early market entry point but would benefit significantly from 5G capability, dramatically increasing the potential to deliver timely services on animal health e.g. c£300M cost for England alone in just beef and sheep, to rural areas. Fertility globally is a huge issue and costs $4bn per year. UK companies have unique offerings to address these trends.

The **UK autonomous agricultural machinery industry** is vibrant and growing, comprising many cutting edge agricultural technology companies and manufactures of systems. Increasingly routine tasks (milking, feed delivery, scraping) are carried out using autonomous robots. Dictated primarily by the weather, farming tasks have often to be carried out within a short time window. Consequently, machines have increased in size to complete operations quickly. Many argue the best solution is for farmers to manage fleets of smaller, autonomous vehicles and carry out tasks as required. The range operations to be delivered include soil chemical analysis, hyperspectral imaging (HSI) of soil/crop condition, real time object level (plant/weed) identification, individual plant harvest readiness assessment (particularly for soft fruits) and plat level automated harvesting. None of this is currently possible because it would be massively labour intensive.

Advanced sensor technology e.g. HSI cameras, represent a component of the solution, in effect the sensor in an Industrial Internet of Agricultural Things (IoAT) application setting. Delivering business value requires the integration of the sensory information with an overall management application requiring communications and data analytics to support understanding. Ultimately minimally sized devices e.g. small tractor or scouting vehicle will be used to carry the sensory equipment e.g. spectral analysis equipment, imaging (visible and HSI). To maximise the flexibility of services, and minimise capital cost, these platforms release multiple customised service provision through a data analysis engine that is customer specific.

Such sensor 'transporters' will be combined with a network of 'actuator' devices: plant level harvesters, precision soil enrichment vehicles or cultivation/planting equipment. It is envisaged that devices will operate jointly on a given task; the sensory element passes over the crop relaying sensory information to a central location. At this location, the data is processed to identify plant, weed, readiness for harvesting and further processing. Following the sensory transporter, the actuator harvests the appropriate plant. The overall system integrates a fleet of small autonomous vehicles accessed from a central pool or shared between neighbours in a co-operative manner. This is possible because the smaller vehicles can operate in a wider range of soil/weather conditions thus extending the useful operational window.

Crop/soil condition mapping

Technologies such as Hyper Spectral imaging (HSI) of arable and grazing areas provides a wealth of information that can be used to determine the precise nutrient requirements at a local level or, for example, to manage grazing. The value of understanding crop (or grass) constituent components, or even biomass is critically important in livestock farming. Optimising feed can be the difference between profit and loss. Currently HSI images are stored locally at the imaging device and are later 'stitched' to provide a map of the area. Significant cost savings are achieved by downloading data in real time in order to perform a quality verification at a minimum of "downtime". While the aircraft is in the near vicinity, the option for

a second fly-over exists thus eliminating the possibility for black spots and the need for a second day of aerial survey.

All mechanised harvesting requires agricultural vehicles to work in close proximity to one another (as little as 1m) at speeds between 2kmh and 15kmh. A high degree of control is required to ensure transfer of produce from the harvester to the tractor-trailer is accurate and safe. Semi-automated systems are available however these rely on human intervention in the event of unexpected or emergency situations. For autonomous agricultural vehicles to become a viable concept, the amount of data that can be reliably transferred real-time from the field to a 'command centre' will have to increase dramatically. Initially this will support the current practice of using an operator to intervene in emergency situations. As capability increases, full automation will be possible provided low-latency is not an issue.

The ability to aggregate detailed sensor information from multiple vehicles operating in the field at a command centre real-time opens up many opportunities; swarm vehicles, informing other vehicles in the swarm of current location, collaboratively creating whole-field maps from sub field missions, informing subsequent operations of current conditions e.g. through soil analysis).

Fully automated harvesting and selective spraying systems represent another lucrative opportunity Selective spraying is highly desirable from cost, environmental and legislative perspectives. Although on the cusp of implementation a number of key technological challenges remain, one being the advantageous features owing to 5G communications. Agronomists working in the field to identify crop issues (pests, black grass) and that core analysis can be complemented with "video-stitched" images (presently RGB but ideal HSI) to map the field more accurately. Drones can be used but the communications link to deliver images to a platform that can perform the stitching into a map in a 'real time' manner does not exist. Pervasive connectivity currently does not exist and therefore SD cards are used to upload the data offline (taking several hours). In the meantime, disease propagation will have occurred and a weather window potentially missed. Enhanced connectivity would facilitate real time processing enabling geolocation spraying instructions to be delivered to an autonomous fleet. The new methodology will support the development of the processes and algorithms that underpin the delivery of other autonomous services (remote drone delivery, driverless vehicle).

Precision Feeding/Grazing

The global dairy market is projected to be worth $449B by 2019. The UK has a relatively small share at approximately £5B per annum (farm gate value). However, UK based technology companies service the global market with devices and overlaid services. Small percentage changes in operational efficiency can represent a significant opportunity for novel businesses, and sustainability for farmers. Present cattle management systems for dairy have

evolved to address the need for oestrus (onset of heat) detection in cattle to optimise fertility. Cattle within the herds are fitted with neck collars that measure small acceleration on the neck and process this to identify activity, eating, rumination patterns and other behaviours. This is classified per animal on a timescale from 10 second intervals to 2 hourly intervals. In the Silent Herdsman system developed in Scotland, 90 second summaries are returned to create a detailed observation history. Short packets are transmitted to minimise battery drain. Additional value can be added to collar based systems through for example integration with signals from robotic milking stations (fat, protein, per quarter conductivity, lactose, milk flow, volume, somatic cell count, progesterone level) providing mechanisms for sensor corroboration. Other welfare/productivity enhancing services can be provided using the same collars combined with additional information, for example location.

Free grazing is the most cost effective way to feed cattle (£0.035 per litre of milk c.f. £0.10 for purchased feed). However, without regular detailed analysis, it is not possible to accurately gauge the grass feed value (energy, protein, dry matter). Maximising the feed value that grazing provides requires both a detailed understanding of the grass composition and animal location. Grass may be optimally grazed for one or two days and then left to recover. Understanding feed composition (either from purchased feed or from grazing) combined with accurate feeding times enables customised feeding regimes to be constructed. If this can be achieved, feed adjustments can be made to the delivery of supplements (targeted concentrates) delivered at milking to maintain energy balance at critical production stages e.g. post calving.

With knowledge of livestock position, and grass quality, geo-fencing (using on collar audio signals to steer cattle to areas where they should be grazing and/or away from areas where they should not be) is a means to optimise grazing practice. This represents a challenge because ideally it should be carried out real time (to take into account previous grazing and weather conditions). Drone based surveys relayed to a cloud service for processing and stitching can input to a service platform that provides the feedback to cattle to move to the optimum grazing location. Rapid edge processing would allow cattle to be grazed in the optimum place, for example before they move to an area that is too wet and potentially damage the future crop. Additionally, at present there is no effective solution to location determination that is power effective. Integrating this information with daily feed analysis data will provide a reliable feedback route to deliver IoAT precision grazing services. There are instances where location alone is of commercial value due to regulatory interests. In some European countries e.g. Holland free grazed animals command a milk/beef premium but requires proof of free grazing. Emerging UK companies like Hoofprints Ltd will be able to fully capitalise on data backhaul capacity.

Precision grazing methodologies apply to precision feeding in general, requiring real time knowledge of the feed composition. Spectroscopic measurements on robotic feeder wagons providing estimates of nutritional content are in their infancy. The target is to provide real time measurement of feed value at the point of distribution (feed value may vary across mix). Present solutions are limited due to a lack of robustness in-field, of analytical models relating spectra to feed value. High bandwidth communications relaying HSI in tandem with the time and delivery location will facilitate cloud processing will accelerate the development of the measurement algorithms and allow herd nutritional programmes to be tailored. The net effect is the delivery of feeds that can be tailored to specific animal needs (through supplements) according to their time in lactation and the milk component (fat/protein ratio) desired for the end product (milk, cheese).

The dairy industry is also challenged with a decreasing availability of labour, particularly of qualified veterinarians, and an increasing demand for high quality animal health management. Inadequate fertility and health management means that the average cow lifetime output of milk is less than 30 tonnes in three lactations while the potential for most cows is over 200 tonnes in 10 lactations. In this respect, ambient computing coupled to human voice command will result in the empowerment of vet technicians and stockpersons to execute on most of the routine treatments (calving, treating production diseases, pregnancy testing, foot trimming). These treatments require physical effort in wet or badly lit environments; so mobile phones are not usable. The deployment of 'smart posts' operating as listening and watching points enable internet-based models to interpret coughs and other characteristic audio outputs from animals to give decision support indications of location specific disease markers or incidents. They can also be used to interrogate veterinary directories for diagnostic models and best clinical practice guidance allowing even the opportunity for augmented reality surgery. These system capabilities are currently standalone because there has been insufficient bandwidth in rural environments. 5G can enable detailed maps of infectious disease risk adding the in-field veterinary data to models of weather effects, bird migrations, animal product trading and pathology reports to enable precision in controlling outbreaks of diseases such as avian flu and TB.

Innovation in Scottish Agriculture; *The Internet of Agricultural Things (IoAT)*

Outline

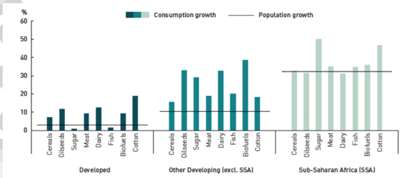
- *Introduction*
  Ivan Andonovic, University of Strathclyde
- *Food Security and Global Opportunities*
  Dave Ross, AGRI-EPI Centre
- *Precision Agriculture; Putting Scotland on the Global Map*
  Willie Thomson, Harbro Ltd
- *IoAT Technologies in Precision Agriculture*
  Ivan Andonovic and Craig Michie, University of Strathclyde
- *Rural Broadband Connectivity*
  Robert Stewart, University of Strathclyde
- *Conclusions/Questions*
  Dave Ross (AGRI-EPI) and Willie Thomson (Harbro)

Food Security and global drivers/opportunities

Dave Ross
Chief Executive Officer

Dave.ross@agri-epicentre.com

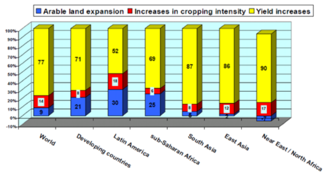
Growth in Food Demand; The Global Perspective



2013-2015 average vs 2025

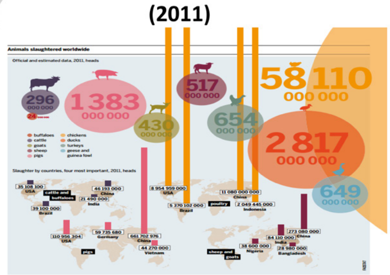
Crops, Global...

Sources of growth in crop production (2005/07 to 2050)

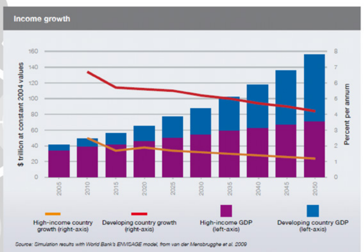


Source: Bruinsma (FAO 2006)

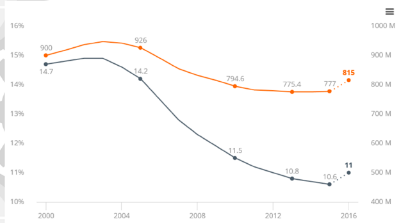
Global Terrestrial Livestock Production (2011)



Food Purchasing Power?



Malnutrition on the Rise?



UN FAO target – end World Hunger by 2030

Precision Agriculture; Putting Scotland on the Global Map

Willie Thomson

Harbro

AGRIEPICENTRE

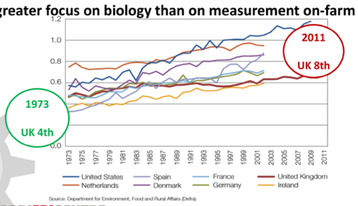
Exciting times!!

- challenges, opportunities……and even Brexit
- **main challenge will be feeding the world in next 20 years**
- we have the opportunity to shape an **Agricultural Revolution**

*"Precision engineering has the potential to be the most disruptive technology available to modern agriculture; as disruptive as biotechnology **was**."*

UK Perspective…..could do better!

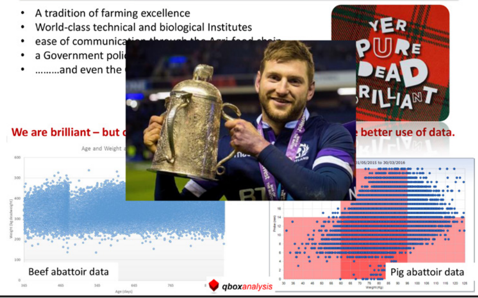
- **backdrop of a relative decline in production efficiency over the past 30 years**
- **a break in the link between production and fundamental science**
- **a greater focus on biology than on measurement on-farm**



A Scottish Perspective

- A tradition of farming excellence
- World-class technical and biological Institutes
- ease of communica
- a Government poli
- ………and even the

We are brilliant – but c **better use of data.**



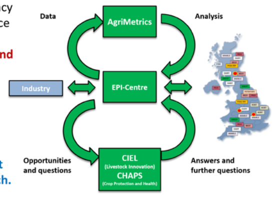
A Changing Landscape

Sensors, robotics, data analytics and systems integration are key to future agriculture – the 'Internet of Farming'

- Scotland has truly world-class skills…….
  - Strathclyde University
  - CENSIS
  - DataLab
  - SEFARI
- ….companies able to innovate globally,
  - Harbro
  - Innovent
  - Afimilk
  - Ice Robotics
  - Soil Essentials
- and new mechanisms to support innovation
  - Agri-EPI Centre
  - SmartFarm

The Way Forward – Systems Integration

- The future requires a systems approach to agricultural efficiency – and a new link between science and progressive agriculture
- **New Agricultural Engineering and Precision Innovation Centre –**
  Agri-EPI Centre
- Network of progressive farms / processing sites all precision monitored
- **Using real data to understand variance – and to drive relevant technical and biological research.**
- **Farm-focussed innovation**



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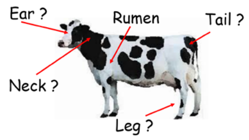
IoAT Technologies in Precision Agriculture

Ivan Andonovic, Craig Michie

University of Strathclyde Engineering

Internet of Cows

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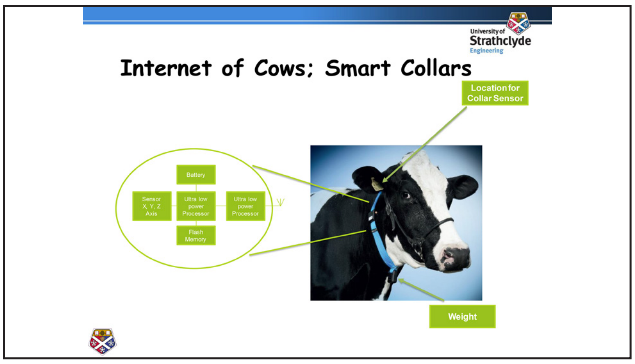
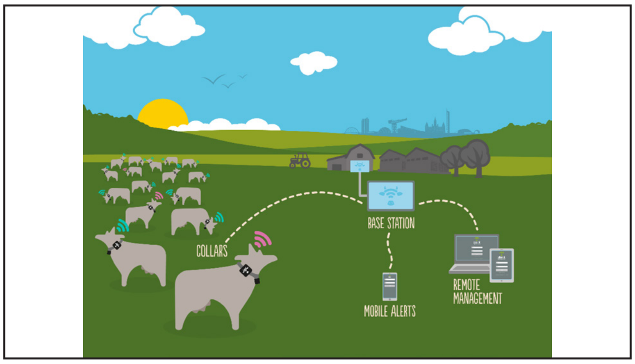
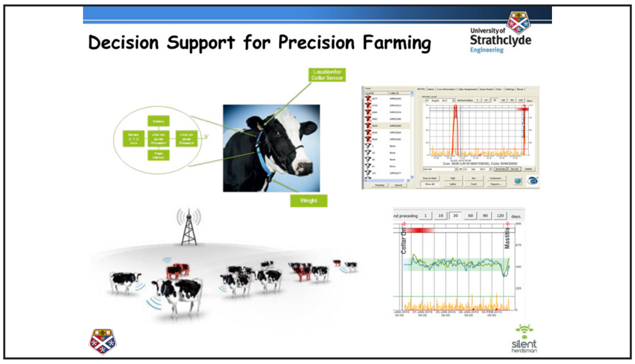
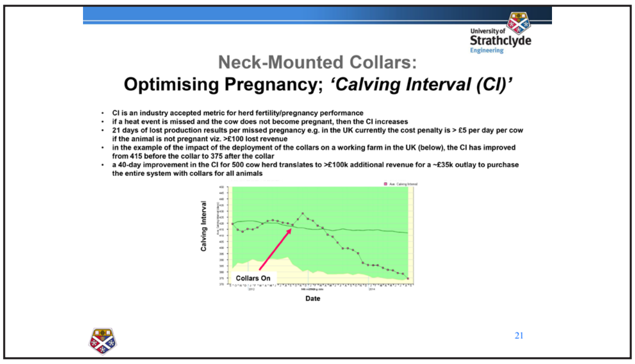
Internet of Cows
17


University of Strathclyde Engineering
Internet of Cows; Smart Collars
Location for Collar Sensor
Battery
Sensor X, Y, Z Axis
Ultra low power Processor
Ultra low power Processor
Flash Memory
Weight


COLLARS
BASE STATION
MOBILE ALERTS
REMOTE MANAGEMENT


Decision Support for Precision Farming
University of Strathclyde Engineering
Weight
silent herdsman


University of Strathclyde Engineering
Neck-Mounted Collars:
Optimising Pregnancy; 'Calving Interval (CI)'
• CI is an industry accepted metric for herd fertility/pregnancy performance
• if a heat event is missed and the cow does not become pregnant, then the CI increases
• 21 days of lost production results per missed pregnancy e.g. in the UK currently the cost penalty is > £5 per day per cow if the animal is not pregnant viz. >£100 lost revenue
• in the example of the impact of the deployment of the collars on a working farm in the UK (below), the CI has improved from 415 before the collar to 375 after the collar
• a 40-day improvement in the CI for 500 cow herd translates to >£100k additional revenue for a ~£35k outlay to purchase the entire system with collars for all animals
Calving Interval
Collars On
Date
21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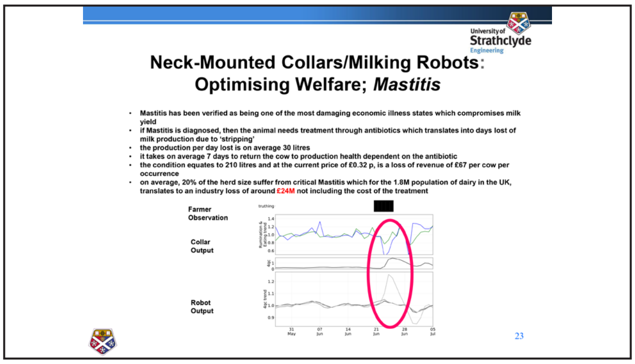
Robots do the Milking
22


University of Strathclyde Engineering
Neck-Mounted Collars/Milking Robots:
Optimising Welfare; Mastitis
• Mastitis has been verified as being one of the most damaging economic illness states which compromises milk yield
• if Mastitis is diagnosed, then the animal needs treatment through antibiotics which translates into days lost of milk production due to 'stripping'
• the production per day lost is on average 30 litres
• it takes on average 7 days to return the cow to production health dependent on the antibiotic
• the condition equates to 210 litres and at the current price of £0.32 p, is a loss of revenue of £67 per cow per occurrence
• on average, 20% of the herd size suffer from critical Mastitis which for the 1.8M population of dairy in the UK, translates to an industry loss of around £24M not including the cost of the treatment
Farmer Observation
truthing
Collar Output
Robot Output
23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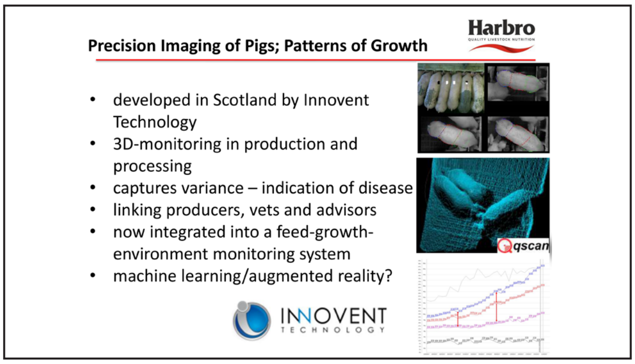
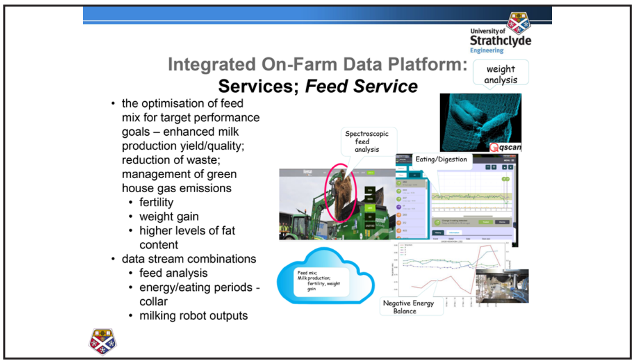
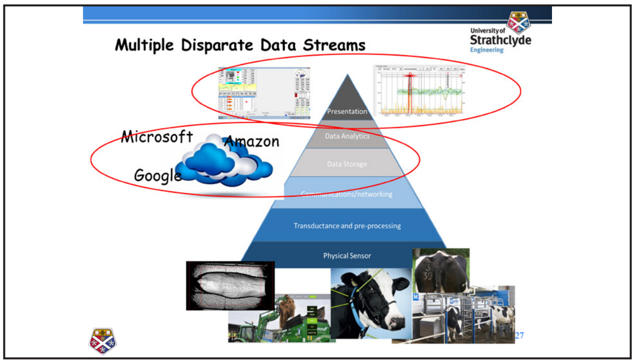
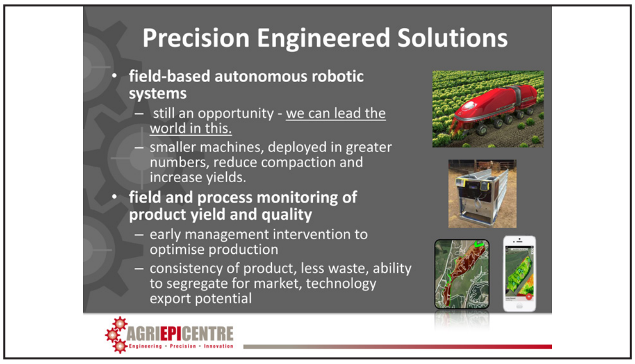
Robots do the Feeding
24


Harbro
Precision Imaging of Pigs; Patterns of Growth
• developed in Scotland by Innovent Technology
• 3D-monitoring in production and processing
• captures variance – indication of disease
• linking producers, vets and advisors
• now integrated into a feed-growth-environment monitoring system
• machine learning/augmented reality?
qscan
INNOVENT TECHNOLOGY


University of Strathclyde Engineering
Integrated On-Farm Data Platform:
Services; Feed Service
weight analysis
• the optimisation of feed mix for target performance goals – enhanced milk production yield/quality; reduction of waste; management of green house gas emissions
• fertility
• weight gain
• higher levels of fat content
• data stream combinations
• feed analysis
• energy/eating periods - collar
• milking robot outputs
Spectroscopic feed analysis
Eating/Digestion
qscan
Negative Energy Balance


Multiple Disparate Data Streams
University of Strathclyde Engineering
Microsoft
Amazon
Google
Presentation
Data Analytics
Data Storage
Transductance and pre-processing
Physical Sensor


Precision Engineered Solutions
• field-based autonomous robotic systems
– still an opportunity - we can lead the world in this.
– smaller machines, deployed in greater numbers, reduce compaction and increase yields.
• field and process monitoring of product yield and quality
– early management intervention to optimise production
– consistency of product, less waste, ability to segregate for market, technology export potential
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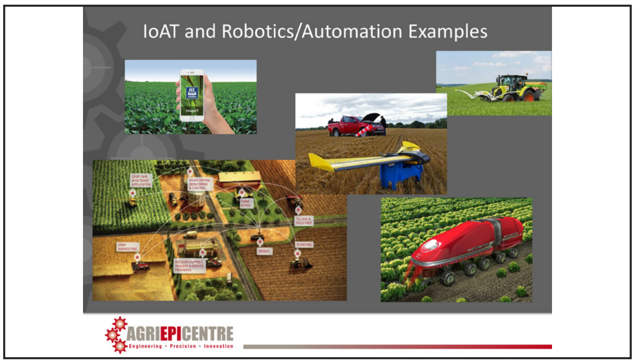
Engineering • Precision • Innovation


IoAT and Robotics/Automation Examples
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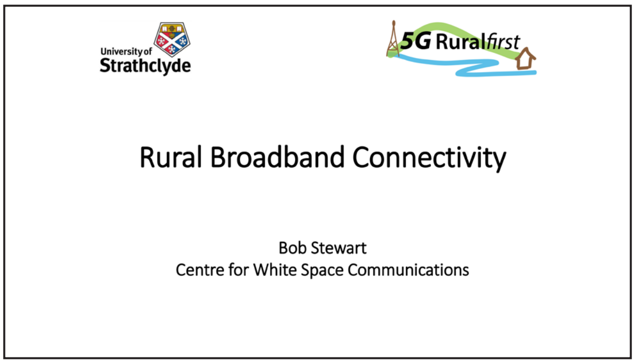
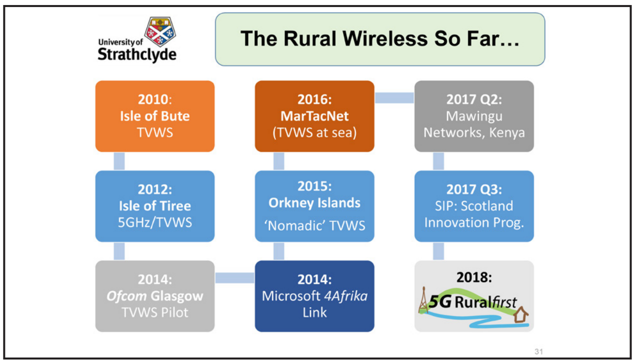

University of Strathclyde
5G Ruralfirst
Rural Broadband Connectivity
Bob Stewart
Centre for White Space Communications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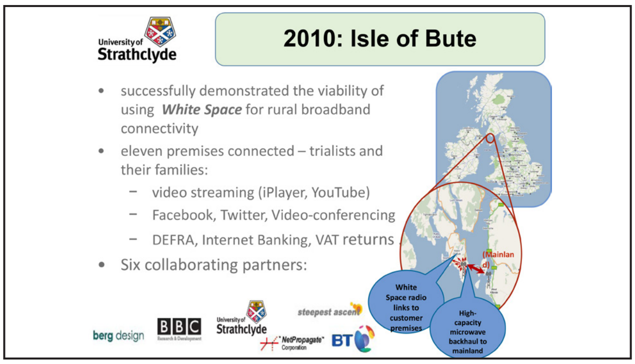
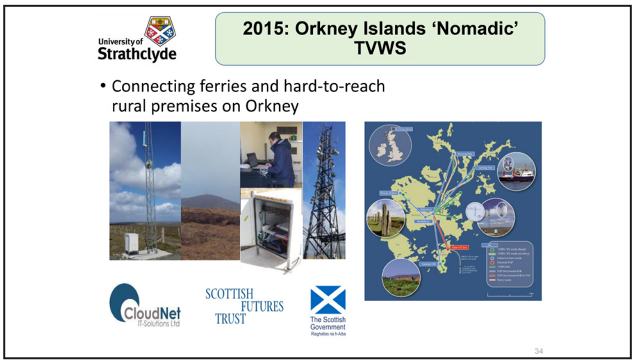
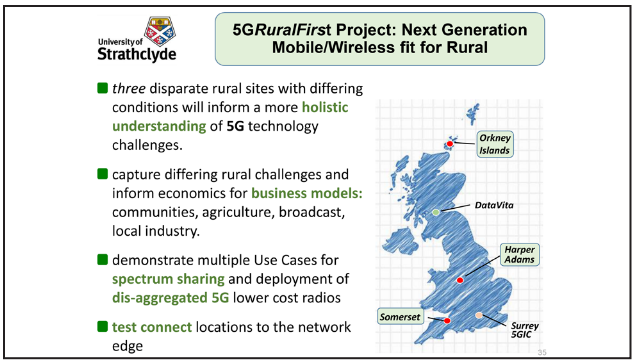
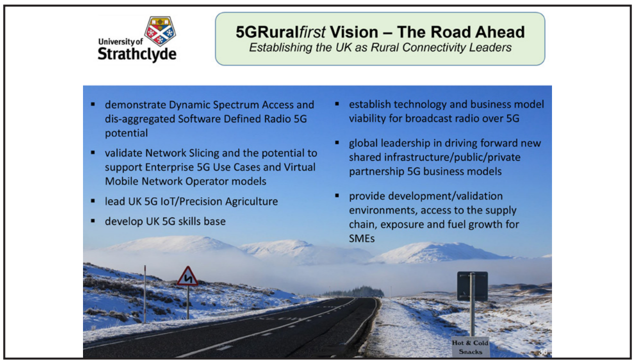
The Rural Wireless So Far…
2010: Isle of Bute TVWS
2016: MarTacNet (TVWS at sea)
2017 Q2: Mawingu Networks, Kenya
2012: Isle of Tiree 5GHz/TVWS
2015: Orkney Islands 'Nomadic' TVWS
2017 Q3: SIP: Scotland Innovation Prog.
2014: Ofcom Glasgow TVWS Pilot
2014: Microsoft 4Afrika Link
2018: 5G Ruralfirst
31

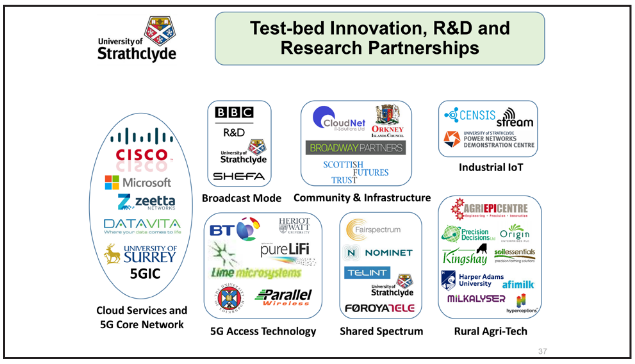

University of Strathclyde
2010: Isle of Bute
• successfully demonstrated the viability of using White Space for rural broadband connectivity
• eleven premises connected – trialists and their families:
– video streaming (iPlayer, YouTube)
– Facebook, Twitter, Video-conferencing
– DEFRA, Internet Banking, VAT returns
• Six collaborating partners:
White Space radio links to customer premises
High-capacity microwave backhaul to mainland
berg design
BBC Research & Development
University of Strathclyde
steepest ascent
NetPropagate Corporation
BT

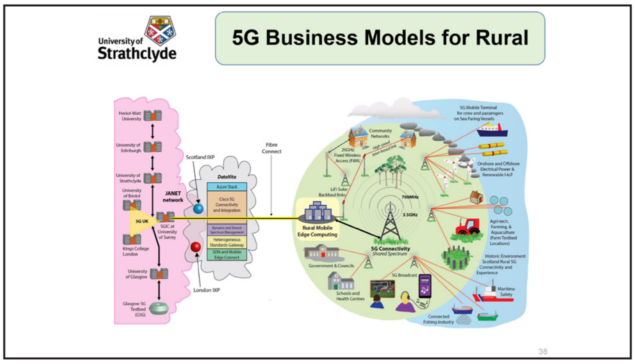

University of Strathclyde
2014: From Scotland to Africa….and bringing ideas back…
Rural Connectivity in Kenya
• 4 Afrika (Microsoft)
• Linking remote villages in rural Kenya
• Radio planning, base station design
• Bucket-Fi (have a look YouTube)
• An Outstanding Success
• www.mawingunetworks.com
MAWINGU
Microsoft
Adaptrum
AFRIKA
VULCAN


University of Strathclyde
2015: Orkney Islands 'Nomadic' TVWS
• Connecting ferries and hard-to-reach rural premises on Orkney
CloudNet
SCOTTISH FUTURES TRUST
The Scottish Government
34


University of Strathclyde
5GRuralFirst Project: Next Generation Mobile/Wireless fit for Rural
three disparate rural sites with differing conditions will inform a more holistic understanding of 5G technology challenges.
capture differing rural challenges and inform economics for business models: communities, agriculture, broadcast, local industry.
demonstrate multiple Use Cases for spectrum sharing and deployment of dis-aggregated 5G lower cost radios
test connect locations to the network edge
Orkney Islands
DataVita
Harper Adams
Somerset
Surrey 5GIC
35


University of Strathclyde
5GRuralfirst Vision – The Road Ahead
Establishing the UK as Rural Connectivity Leaders
▪ demonstrate Dynamic Spectrum Access and dis-aggregated Software Defined Radio 5G potential
▪ validate Network Slicing and the potential to support Enterprise 5G Use Cases and Virtual Mobile Network Operator models
▪ lead UK 5G IoT/Precision Agriculture
▪ develop UK 5G skills base
▪ establish technology and business model viability for broadcast radio over 5G
▪ global leadership in driving forward new shared infrastructure/public/private partnership 5G business models
▪ provide development/validation environments, access to the supply chain, exposure and fuel growth for SMEs
Hot & Cold Snacks
36


University of Strathclyde
Test-bed Innovation, R&D and Research Partnerships
CISCO
Microsoft
zeetta
DATAVITA
UNIVERSITY OF SURREY
5GIC
Cloud Services and 5G Core Network
BBC R&D
Strathclyde
SHEFA
Broadcast Mode
CloudNet
ORKNEY
BROADWAY PARTNERS
SCOTTISH FUTURES TRUST
Community & Infrastructure
CENSIS
stream
Industrial IoT
BT
HERIOT WATT
pureLiFi
Lime microsystems
Parallel Wireless
5G Access Technology
Fairspectrum
NOMINET
TELINT
Strathclyde
FØROYATELE
Shared Spectrum
AGRIEPICENTRE
Precision Decisions
Origin
Kingshay
Harper Adams University
afimilk
MILKALYSER
Rural Agri-Tech
37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5G Business Models for Rural
38


Conclusions
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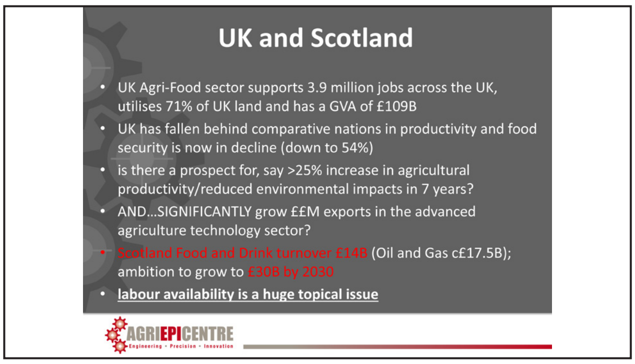
UK and Scotland
• UK Agri-Food sector supports 3.9 million jobs across the UK, utilises 71% of UK land and has a GVA of £109B
• UK has fallen behind comparative nations in productivity and food security is now in decline (down to 54%)
• is there a prospect for, say >25% increase in agricultural productivity/reduced environmental impacts in 7 years?
• AND…SIGNIFICANTLY grow ££M exports in the advanced agriculture technology sector?
• Scotland Food and Drink turnover £14B (Oil and Gas c£17.5B); ambition to grow to £30B by 2030
• labour availability is a huge topical issue
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Engineering • Precision • Innovation

Key opportunity areas

- **Global Precision Agriculture - $10B p.a. by 2024**[1]
  - Variety of technologies for crop and livestock
- **Global Autonomous Farm Equipment Market predicted to be worth $440bn by 2024, over 7.5M units p.a.**[2]
  - requires huge investment in IoAT solutions
  - requires high level connectivity (5G)
  - requires significant investment in value engineered autonomous solutions and crucially, companies to drive this growth.

1. *Global Market Insights, Feb 2018*
2. *Global Market Insights Dec 2017*

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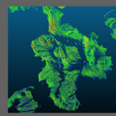
Precision Engineered Solutions



- **"Early and localised pest or disease treatment using technologies to detect (84.5% savings in pesticides possible)**
- **"Variable rate nitrogen fertiliser application according to crop requirements and weather conditions (Reduction of residual Nitrogen in soils by 30 % to 50 %)"** ***(Intercropping could reduce this further).***

- **"Half of the dairy herds in north-western Europe will be milked by robots in 2025."**

Source "Precision agriculture and the future of farming in Europe" European Parliament Scientific Foresight report, December 2016.

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The Way Forward – Global Systems Integration

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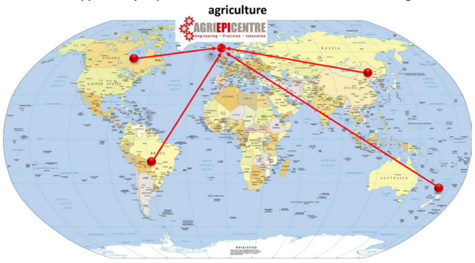
A new opportunity to put the UK and Scotland back at the centre of global agriculture



The Way Forward – 'SmartFarm'

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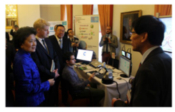
- new UK opportunity
- using the latest sensor technologies to understand whole-chain efficiency
- may be adopted as key UK-China project
- extensive Scottish involvement
  - Strathclyde University
  - Glasgow University
  - James Hutton Institute
  - Agri-EPI Centre
  - Harbro
  - Innovent Technology
  - Afimilk
- will change the efficiency of food production



Summary

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- a crucial time for agriculture
- Scotland is absolutely at the cutting edge in new technologies
- needs to be a real, and concerted effort to drive forward and make use of this *potentially short-term* advantage
- Scotland must understand the importance of the opportunity, and give clear support to creating a more integrated system
- **an opportunity to create a more dynamic, resource efficient Scottish agriculture – one which is both resilient and globally relevant.**

Key Opportunities and How to Unlock?

- using technology to optimise inputs/outputs.
- aligned supplier input growth
  - e.g. global feeds market >1B tonnes
- are we aligning pre-competitive R&D spend/capacity correctly? (SFC/RESAS/SE)
- do we have the correct innovation environment in place to deliver?
- are we encouraging high-growth spin-outs/start-ups to capitalise, and how can this be fostered?

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How to Progress

- Scotland has unique expertise in:
  - agricultural science
  - enabling technologies e.g. ICT and robotics
  - how to engineer into end-to-end solutions that enable sustainable systems
- a new framework to capitalise on these for the benefit of Scotland is needed
- would welcome an opportunity to engage with Government and key stakeholders

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THANK YOU

Questions?

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