



The Role of Data in the Future of Dairy Farming



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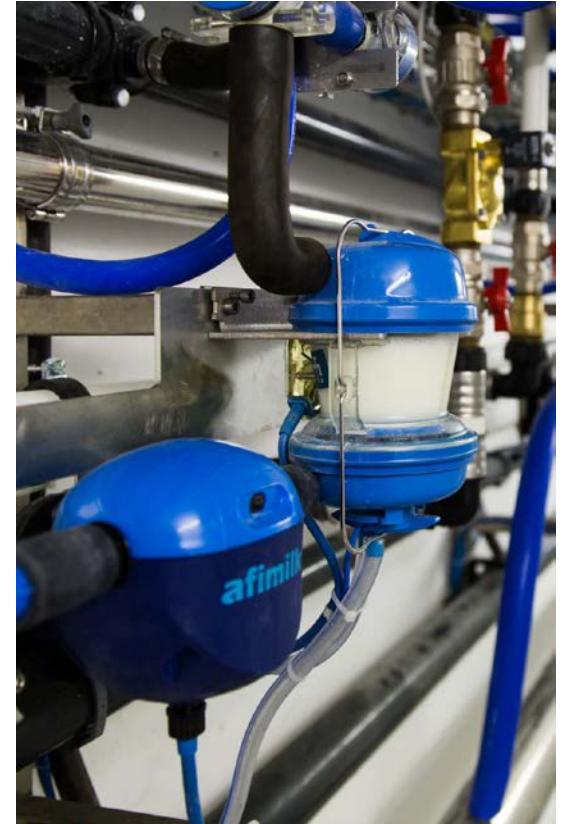
Moorepark2017

STATE OF THE ART

- Precision dairy tech overview - what can be measured?
- **PRODUCTION PERFORMANCE**
 - Milk yield
 - Milk quality
- **HEALTH**
 - Mastitis
 - Fertility
 - Locomotion
 - Metabolism
- **BEHAVIOUR**
 - Physical behaviour
 - Feeding/rumination
 - Spatial behaviour
 - Social behaviour
- **Types of sensors**
 - **ATTACHED**
 - **On-cow sensors** - fitted on the outside of the cow's body (e.g. pedometer)
 - **In-cow sensors** – placed inside the body (e.g. rumen bolus)
 - **NON ATTACHED**
 - **In-line sensors** – take measurements in a continuous flow (e.g. milk meter)
 - **On-line sensors** - automatically take samples (e.g. herd navigator)
 - **On-site sensors** - automatically measure cows' characteristics while they pass through (e.g. walk-through weighing system)

MILK YIELD AND QUALITY

- **MILK YIELD**
 - In-line sensors placed “in” the milk line
 - Different kind of technologies
 - Weighing discrete intervals
 - Continuous flow meters
 - Deliver milk yield/cow*milking and flow rate
- **MILK QUALITY**
 - In-line (or on-line) sensors placed “in” the milk line
 - Usually cow level but could be placed on the main parlour line to make it herd level
 - Usually optical sensors
 - Deliver: fat, protein, lactose
 - Same sensors used to monitor various health traits



HEALTH: MASTITIS

NON-ATTACHED SENSORS

- **Milk electrical conductivity meters** (in-line)
- **Milk colour** (optical sensor, in-line)
- **Biosensors** (herd navigator, on-line)
 - Measurements of LDH (Lactate dehydrogenase, spectrometry)
- **SCC sensors** (on-line)
 - Performing CMT (California Mastitis Test) automatically
- **Infrared thermography** (on-site)
 - udder skin surface temperature

ATTACHED SENSORS

- **Physical activity monitors** (on-cow) (pedometers/accelerometers)
 - By measuring **variations in laying and standing behaviour**
 - Still being developed

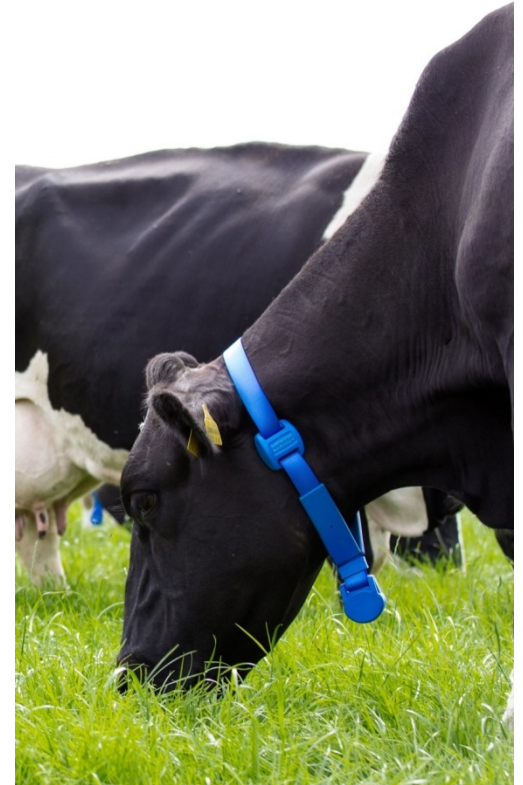
HEALTH: FERTILITY

Automatic **oestrus detection** is the most spread precision tech in dairy farms

ATTACHED SENSORS (on-cow)

- **Physical activity monitors** (pedometers/accelerometers)
 - Attached to cow's **leg**, to the **ear**, or head(**neck**)-mounted
 - **Pedometers** typically measure just **number of steps**
 - **Accelerometers** can measure a wide range of **physical activities**
 - **Heat is detected by measuring deviation from normal activity/behaviour**

*Monitoring activity for heat detection: Sensitivity ~80–90%; Specificity >90%



HEALTH: LOCOMOTION

Lameness detection has been investigated in several studies but sensors seem to be able to **detect just severe locomotion problems** (too late)

ATTACHED SENSORS

- **Physical activity monitors (on-cow)**
 - By measuring **walking behaviour**
 - By measuring **variations in laying behaviour**

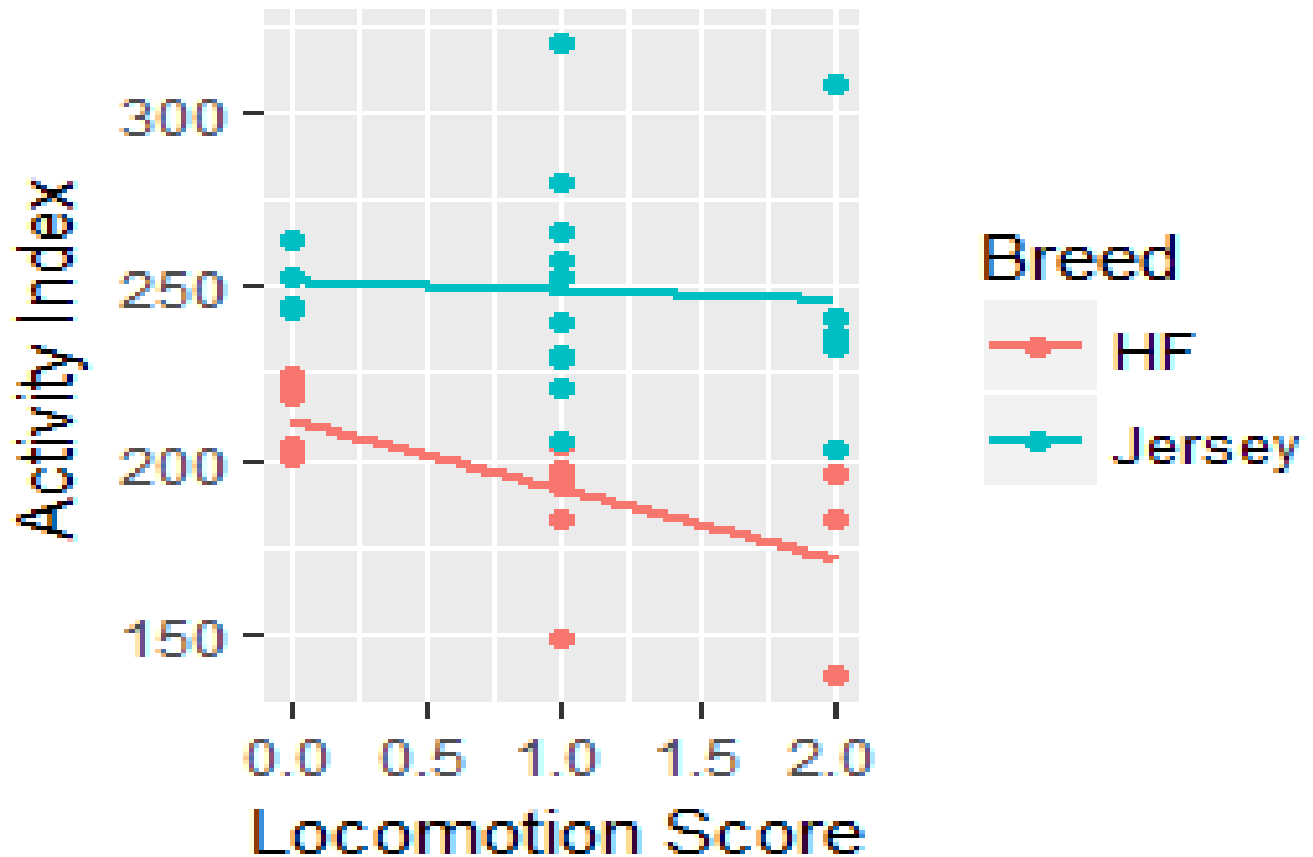
NON-ATTACHED SENSORS

- **Load cells (on-site)**
 - Measurements of walking cows
 - Measurements of standing cows
- **Pressure-sensitive position mat (Gaitwise; on-site)**
 - Seem to be capable of early detection
- **Automated video analysis (on-site)**



Rumi Watch – Strong associations with HF – especially activity index – but not with Jerseys

Activity index: The averaged variance of 3-dimensional acceleration in 10-s segments' (Alsaad *et al.*, 2015)



HEALTH: METABOLISM

ATTACHED SENSORS

- **Physical activity monitors** (on-cow) (pedometers/accelerometers)
 - By measuring **variations in feeding time** (ketosis, metritis)
- **Sensors to monitor rumination behaviour** (on-cow)
 - Acoustic sensor (SCR/MooMonitor) or pressure sensors (IGER/RumiWatch)
- **Radiotelemetric rumen boluses** (in-cow)
 - Measurement of rumen pH (and temperature)

NON-ATTACHED SENSORS

- **Fat, protein, lactose and urea sensors** (in-line)
 - Optical sensor (mostly NIR spectroscopy)
- **Biosensors** (herd navigator, on-line)
 - Measurements of BHB (beta-hydroxybutyrate, spectrometry)
- **Body weight and BCS** (on-site)
 - Walk through weighing scales
 - Camera (2D or 3D) and image processing to detect BCS (and weight)

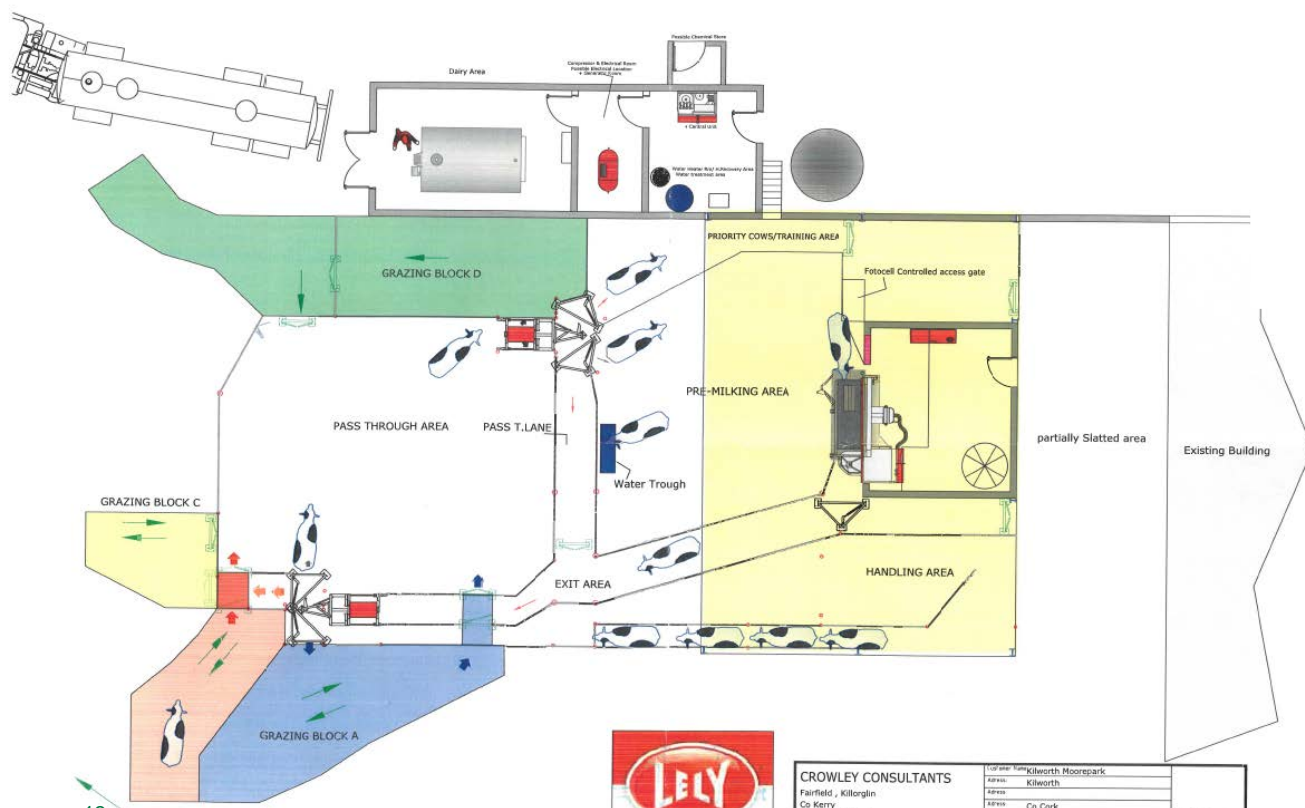
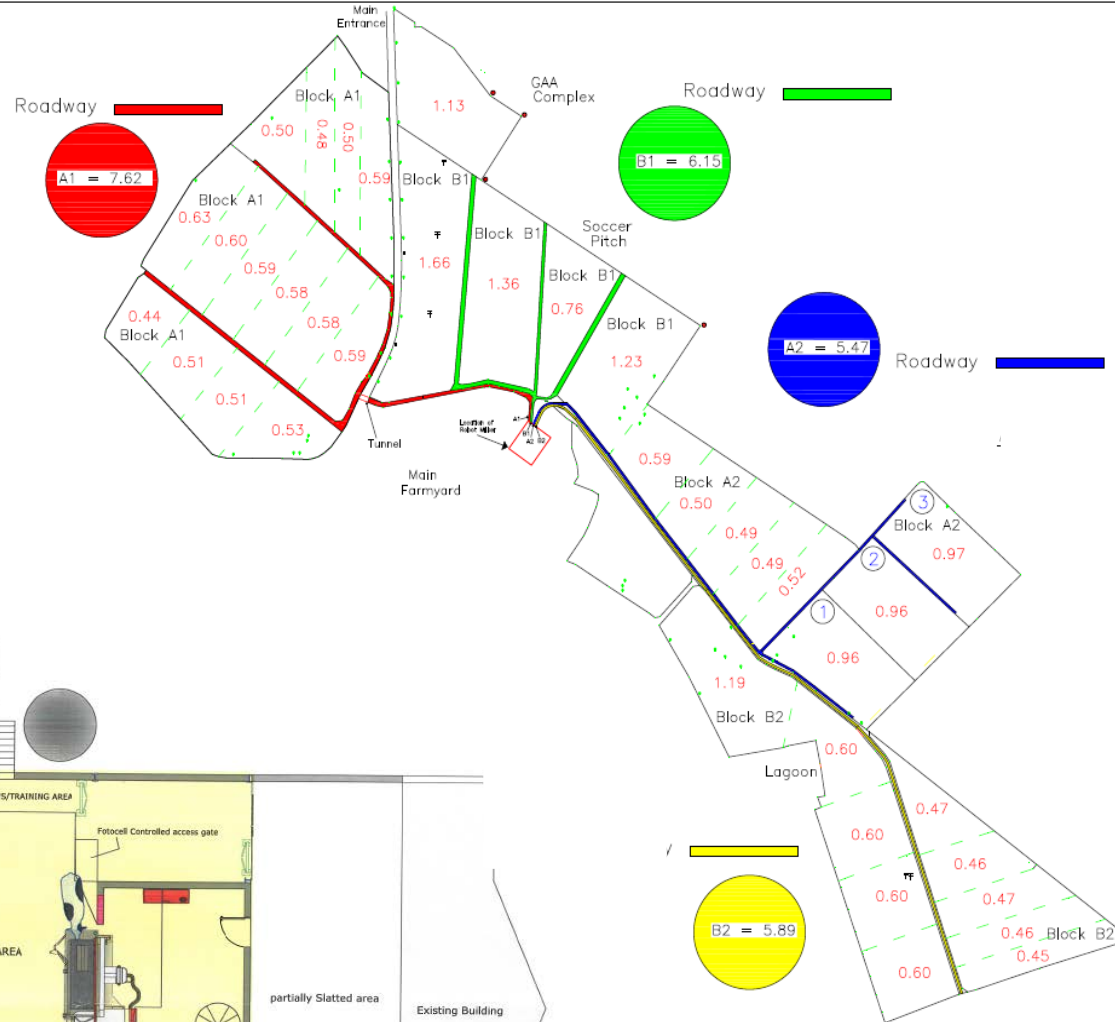
BEHAVIOUR: SPATIAL ACTIVITY

ATTACHED SENSORS

- **GPS-based collars (on-cow)**
 - Monitor position of the cows
 - Deliver world coordinates (data management is time consuming).
 - Main issue is short **battery life**
 - Battery consumption depends on number of fixes in time
 - Precision depends on sensor but usually around 2-8 m
- **Non-GPS positioning systems (on-cow)**
 - **Triangulation** with known position antennas
 - Developed for confinement but could be applied in pasture-based systems
 - Reduced battery consumption

NON-ATTACHED SENSORS

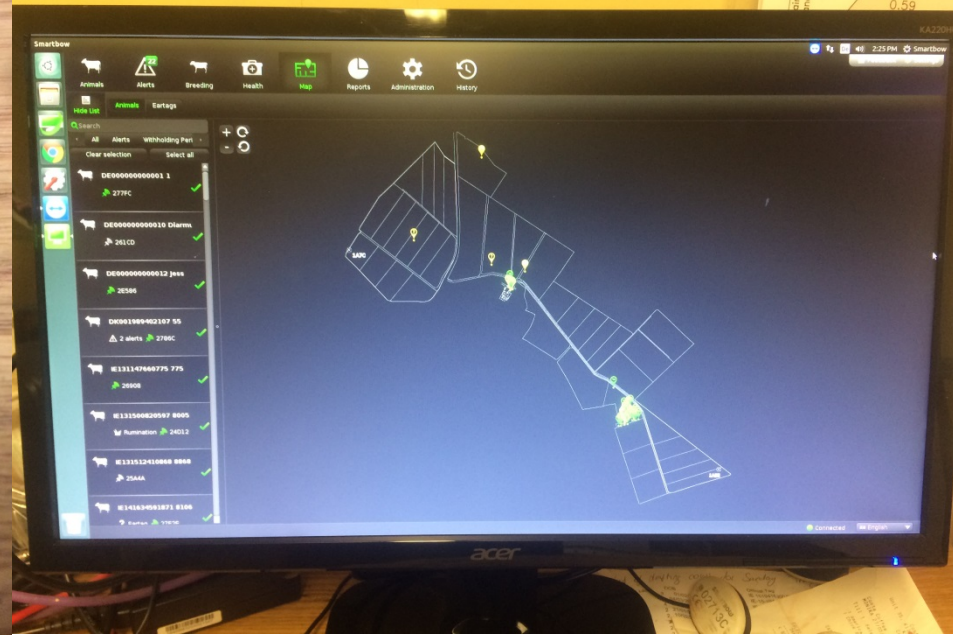
- **Automated video analysis (on-site)**
 - Developed for confinement systems



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SMARTBOW



A/B MONITORS



ITIN+HOCH RumiWatch

- Noseband Sens.(Acc.+Press.) + Pedom.



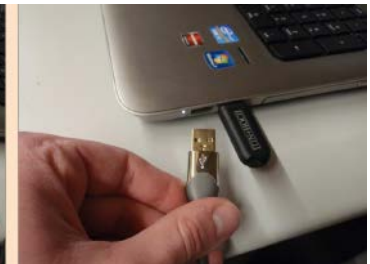
DAIRYMASTER MooMonitor +

- Collar (Accelerometer)

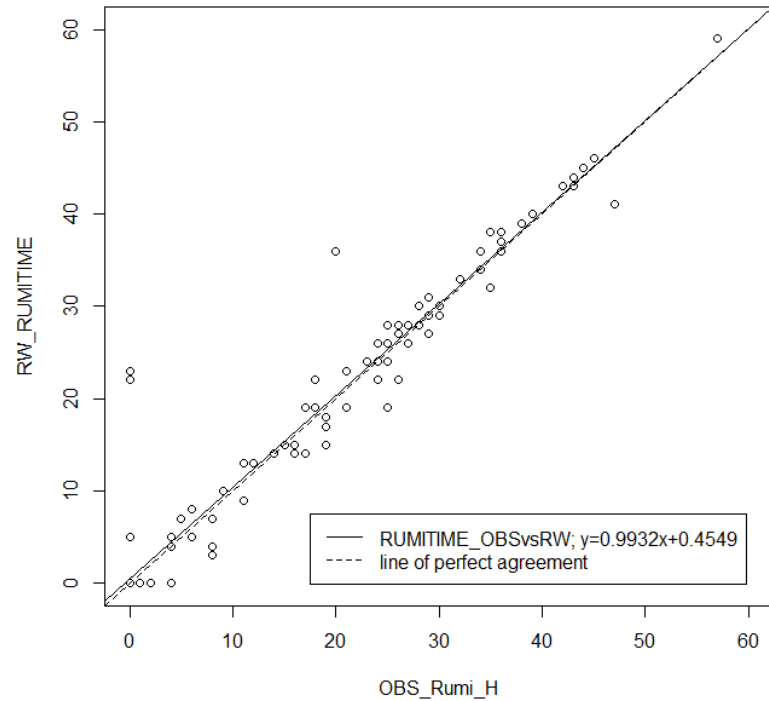
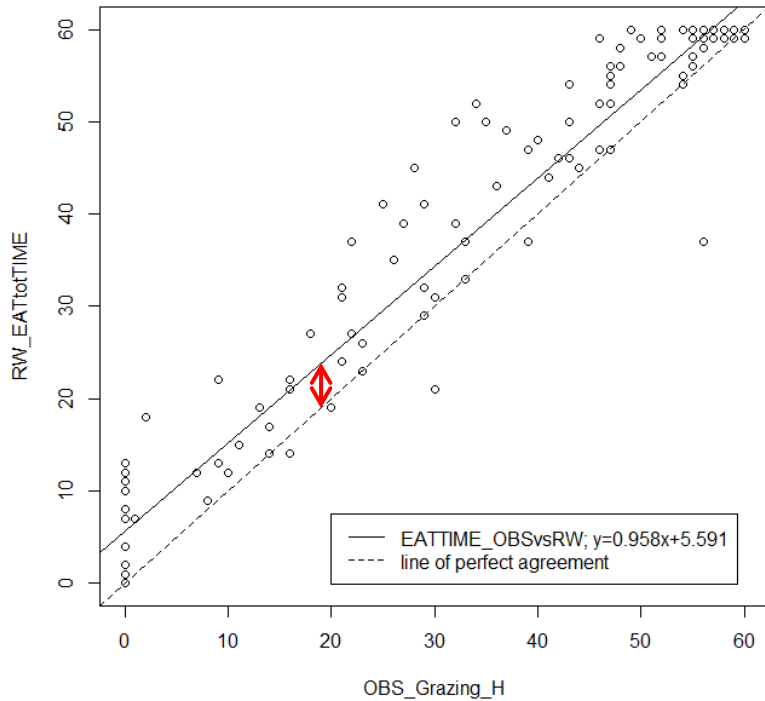


RUMIWATCH NBS

- Noseband pressure sensor (NBS)
- Measures jaw movements (10Hz)
- Rumination, Eating and Drinking activity
- Developed for research purposes (very accurate but expensive)



RW VALID: EAT/RUMI TIME (mins/h)

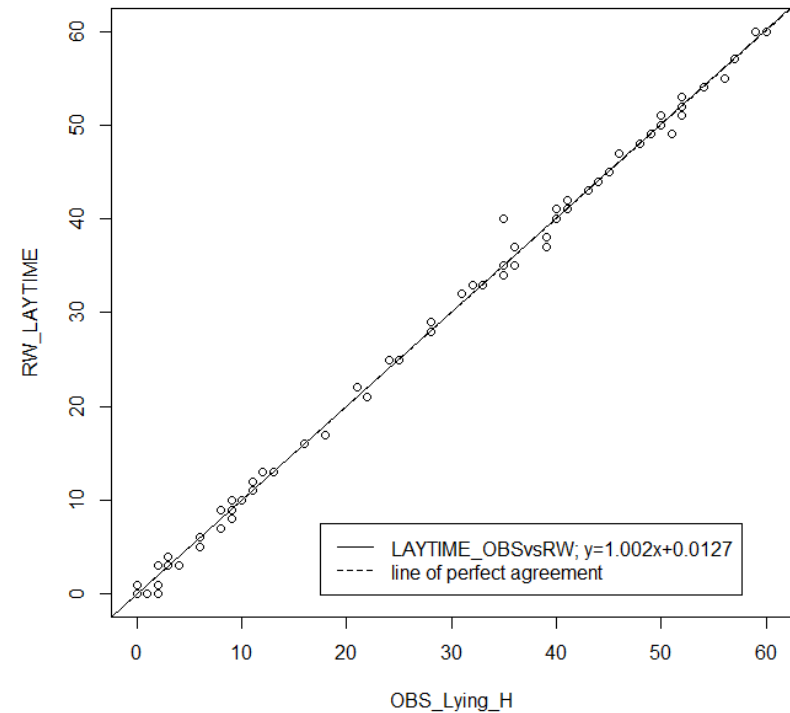
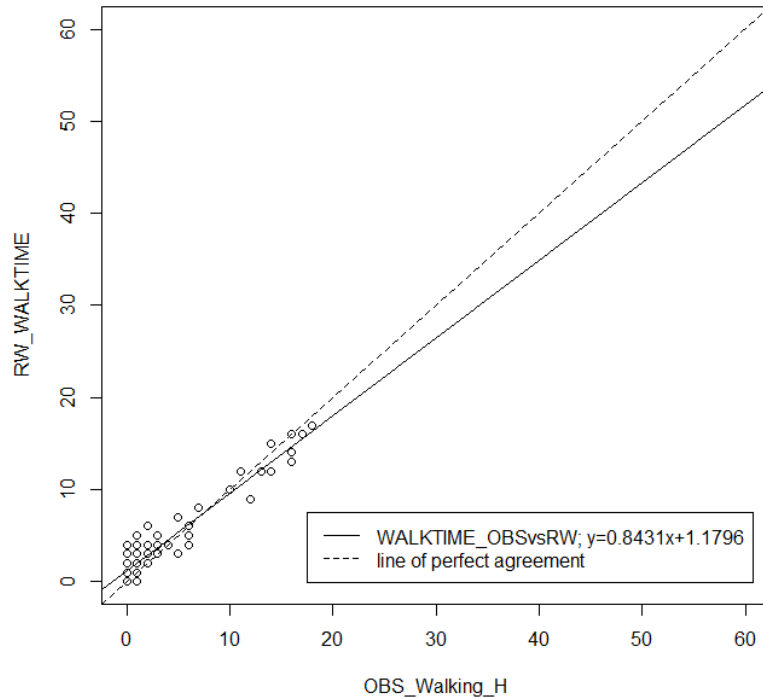


	Spearman's rho	CCC
EATTIME	0.9570	0.9577

	Spearman's rho	CCC
RUMITIME	0.9546	0.9741

RW VALID: WALK/LAY TIME

(mins/h)

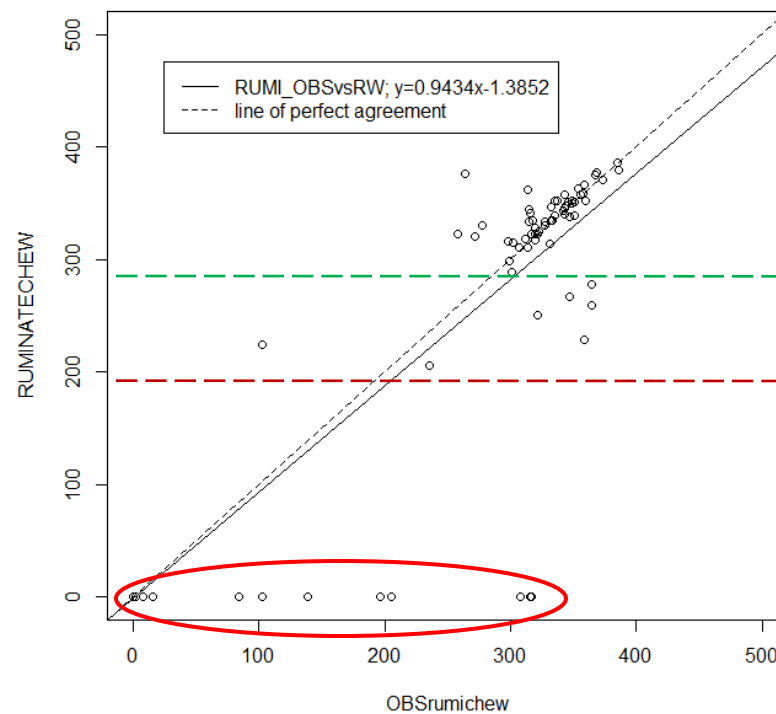
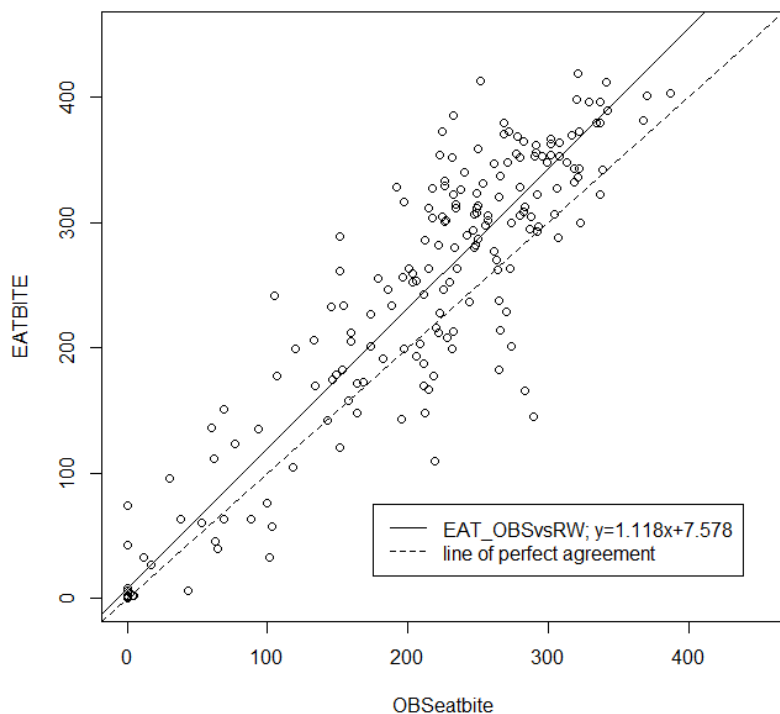


	Spearman's rho	CCC
WALKTIME	0.7754	0.9181

	Spearman's rho	CCC
LAYTIME	0.9911	0.9994

RW VALID: EAT/RUMI CHEWS

(chews/5mins)



	Spearman's rho	CCC
EATBITE	0.7754	0.9577

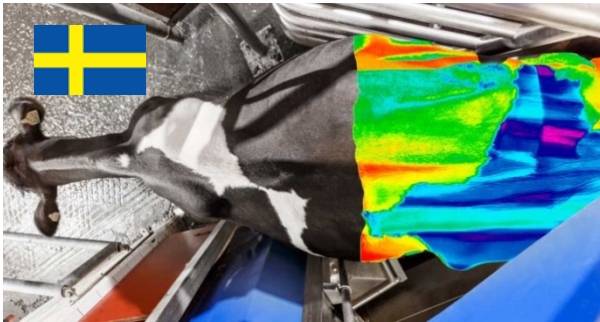
	Spearman's rho	CCC
RUMICHEW	0.9238	0.9501

AUTOMATIC BCS SYSTEMS



- **INGENERA BodyMat**

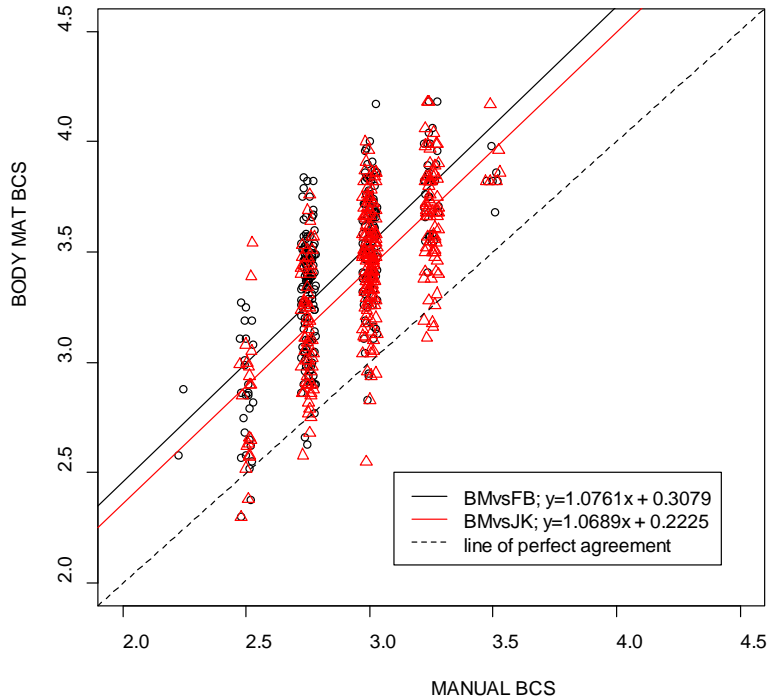
- Based on 2d camera (with laser lines)
- Images are sent to an external server for processing
- Will be tested in the Teagasc's Dairy Gold Farm



- **DELAVAL BCS**

- Based on 3d camera (combination of 2x2d cameras)
- Commercially available system
- Will be tested in an external commercial farm

BODYMAT (BCS) VALIDATION



- Intercepts suggest that the BM overestimated BCS (by 0.22-0.3)
- Slopes (~ 1) indicate that the error is consistent at different BCS.
- Very poor agreement (probably due to overestimation)
- MAE about 15% of the mean

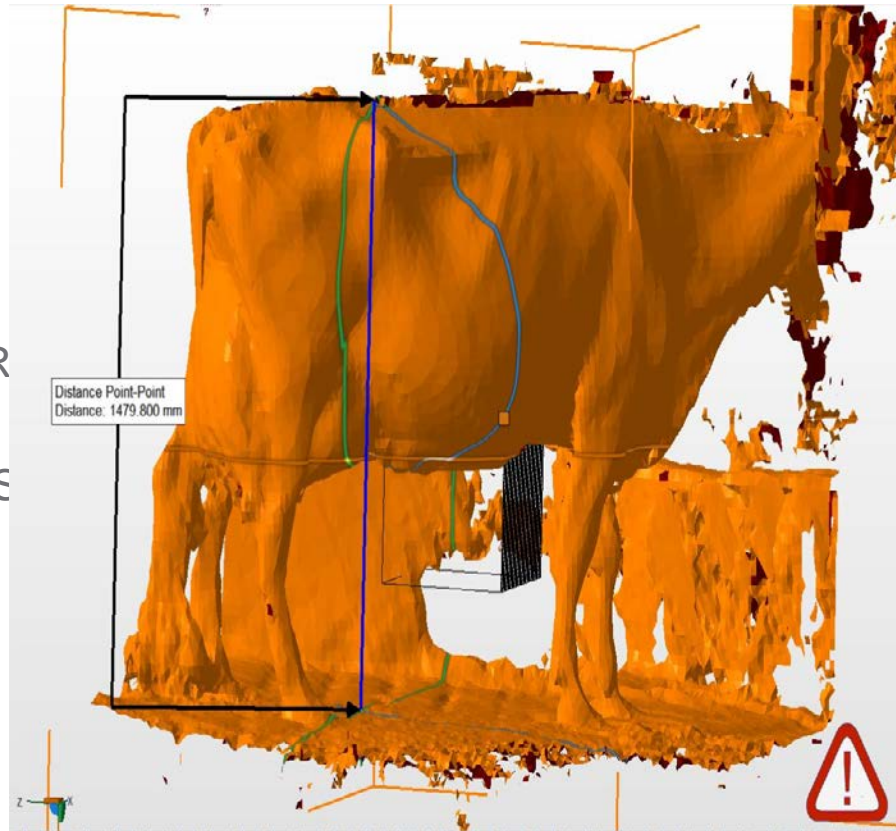
Item	CCC(rm)	MAE	RMSE
BM vs FB	0.244	0.533	0.585
BM vs JK	0.292	0.440	0.498
FB vs JK (agree. obs)	0.666	0.134	0.192

Visual Assessment



LINEAR MEASURES:

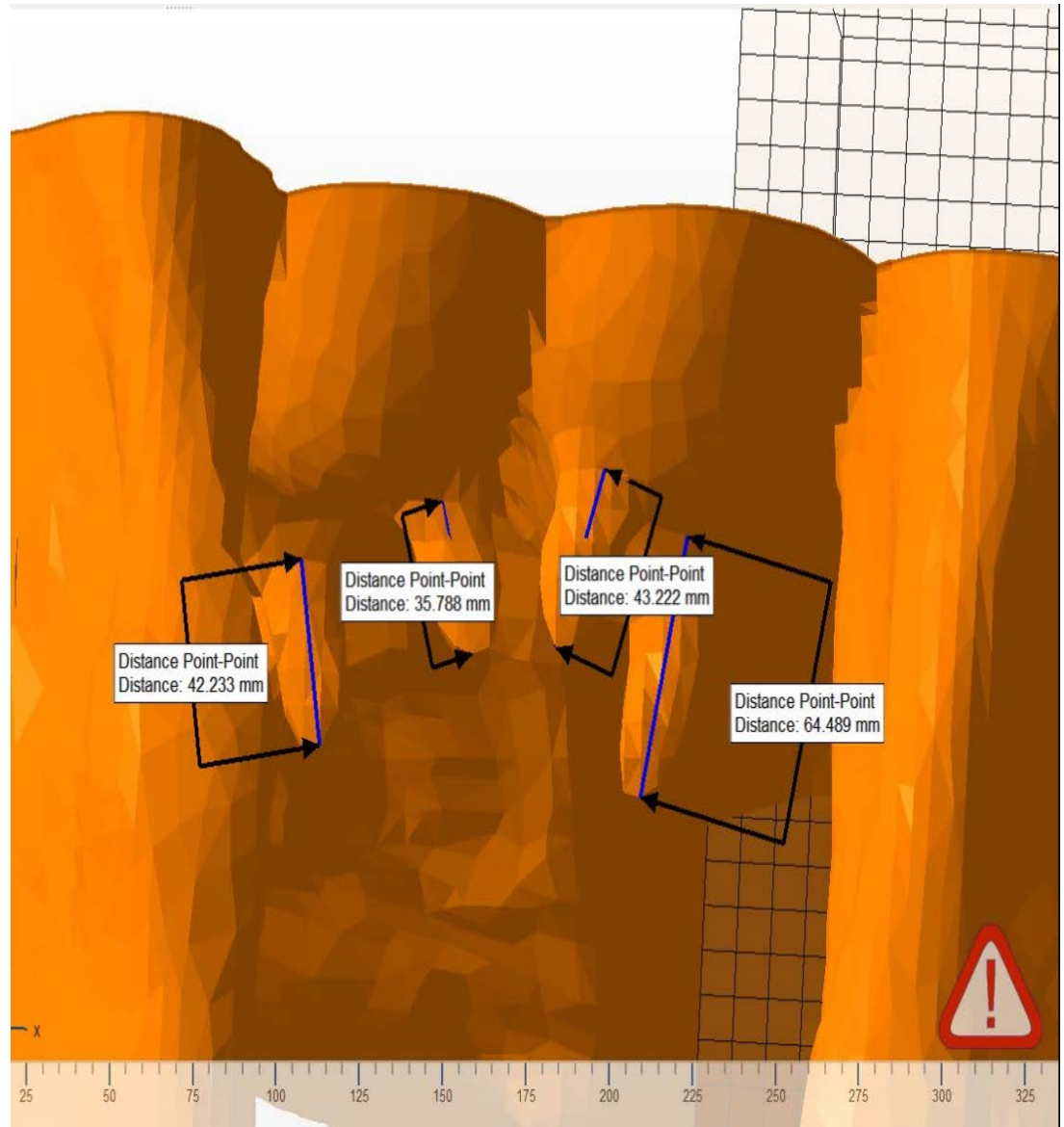
BODY LENGTH
BACK LENGTH
CHEST WIDTH
THURL WIDTH
BODY DEPTH
CHEST DEPTH
FLANK DEPTH
LENGTH OF RUMP
HEIGHT AT WITHER
HEIGHT AT RUMP
ROUNDING OF RIBS
RUMP ANGLE
TAIL SET
WIDTH AT HIPS



- WIDTH AT PINS
- MUSCULARITY SHOULDER
- BACK WIDTH
- THICKNESS OF LOI
- THIGH ROUNDING
- THICH WIDTH
- THIGH LENGTH
- MUZZLE WIDTH
- TOP LINE
- FRONT LEGS
- FORE PASTERNS
- REAR LEGS SET
- CLAW ANGLE
- THICKNESS OF BONE

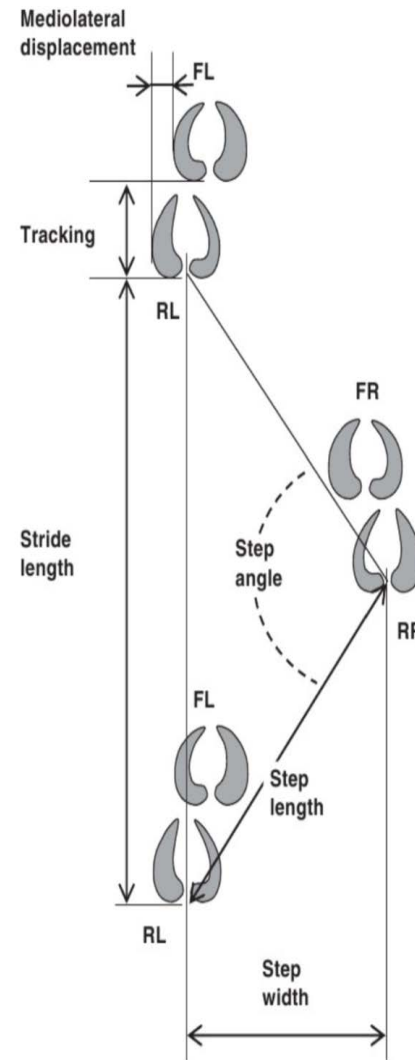
MAMMARY TREATS

- THICKNESS OF TEAT
- TEAT LENGTH
- UDDER BALANCE
- UDDER DEPTH



LOCOMATION:

HEAD APPLITUDE
HEAD FREQUENCY
GAIT ANALYSIS
STRIDE LENGTH
SPEED

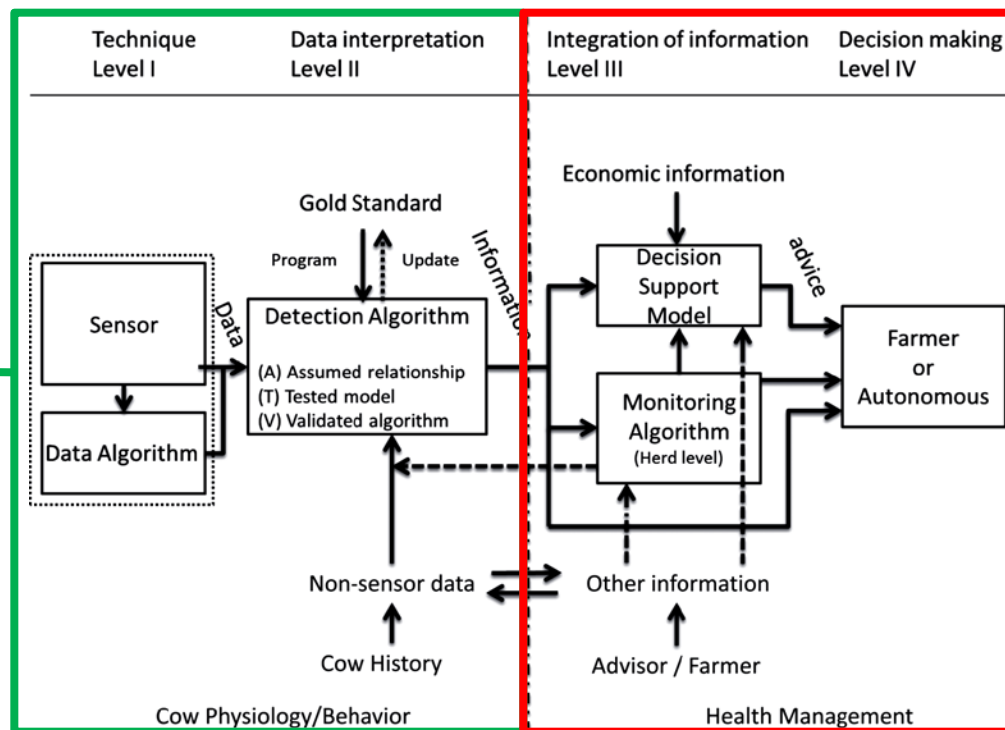


The Technology Works BUT

- Useful Outputs

SENSORS DEVELOPMENT

126 published studies describing
139 sensor systems for animal
health management (till 2013)



NO (or very few) studies

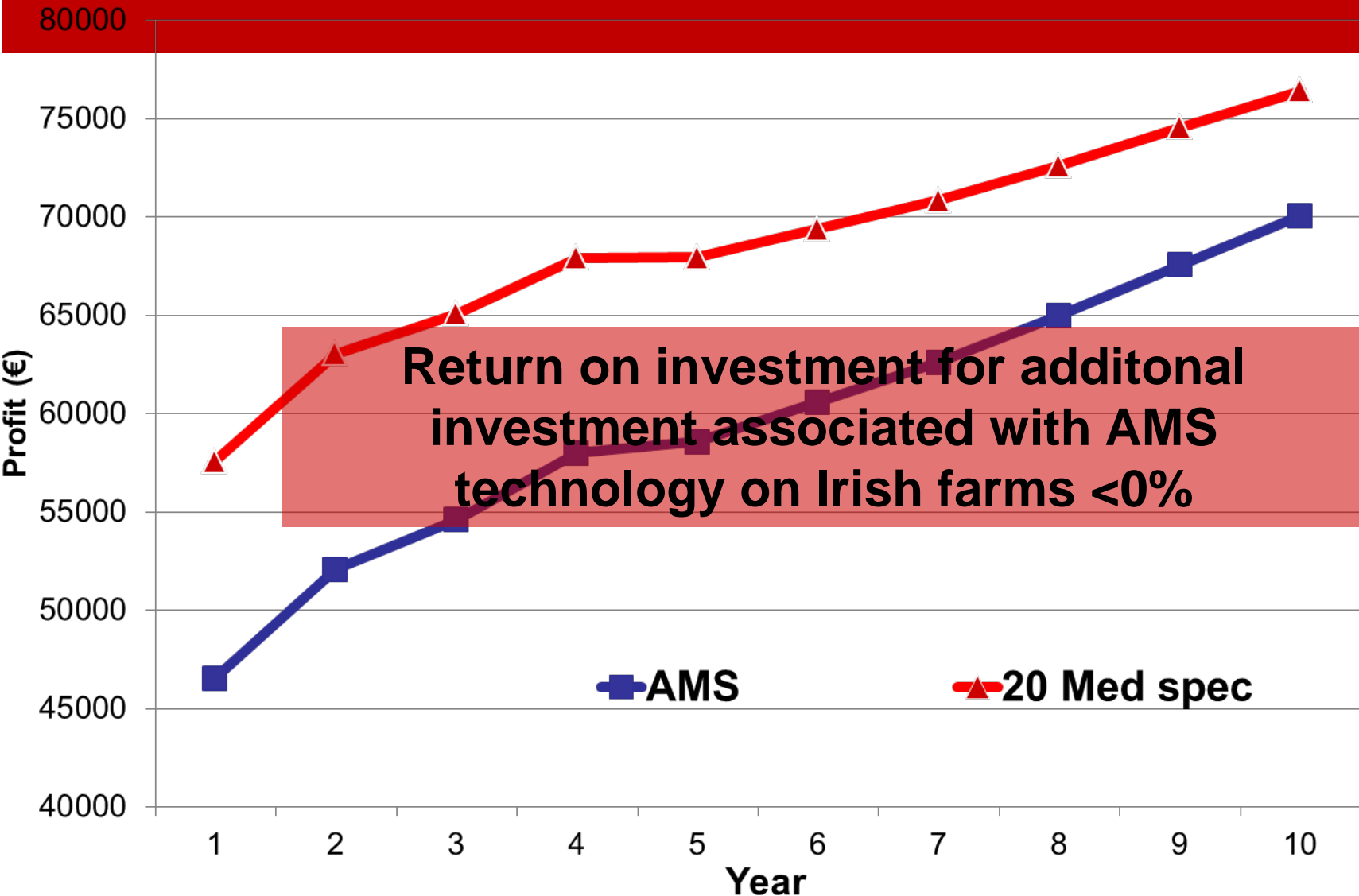
Rutten et al., 2013. Invited review: Sensors to support health management on dairy farms. J. Dairy Sci. (also known as "The Great")

- **Productivity did not change after investment in sensor systems on dairy farms (Steeneveld et al., 2015)**

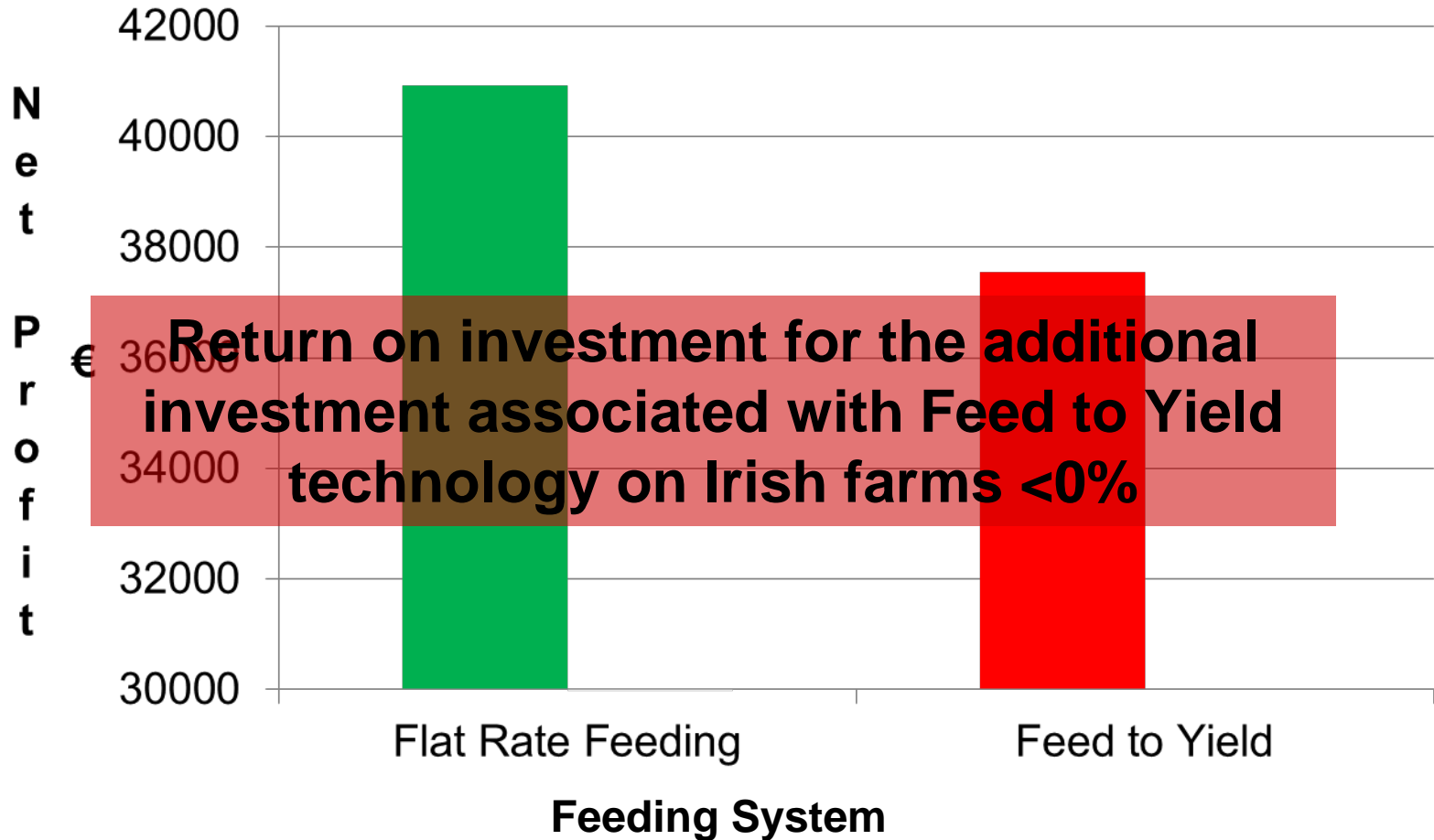
The Technology Works BUT

- Useful Outputs
- Return for investment made

AMS Versus Conventional Milking systems



Feed to Yield Milking systems



The Potential from Precision technologies

- Farm Level
 - Increase the decision making process;
 - More information
 - Accurate information
 - Timely information
 - Interpreted information
- Industry level
 - More accurate genetic evaluations
 - Grass evaluation
 - Sustainability measurement and verification

Huge Potential

Focus area

- By and large the technologies can measure what they are supposed to measure
- There is a requirement to validate all technologies
- However the focus must be on application
 - Short term Decision making
 - Grass wedge

Key challenge now is to develop systems to utilise the data and maximum return for the various end-users

Medium Term Decision making

- Take out silage cut
- Body condition score management
- Locomotion scoring
- Long Term Decision making
 - Genetic evaluations
 - Grass evaluations

Providing Solutions through integrated Systems

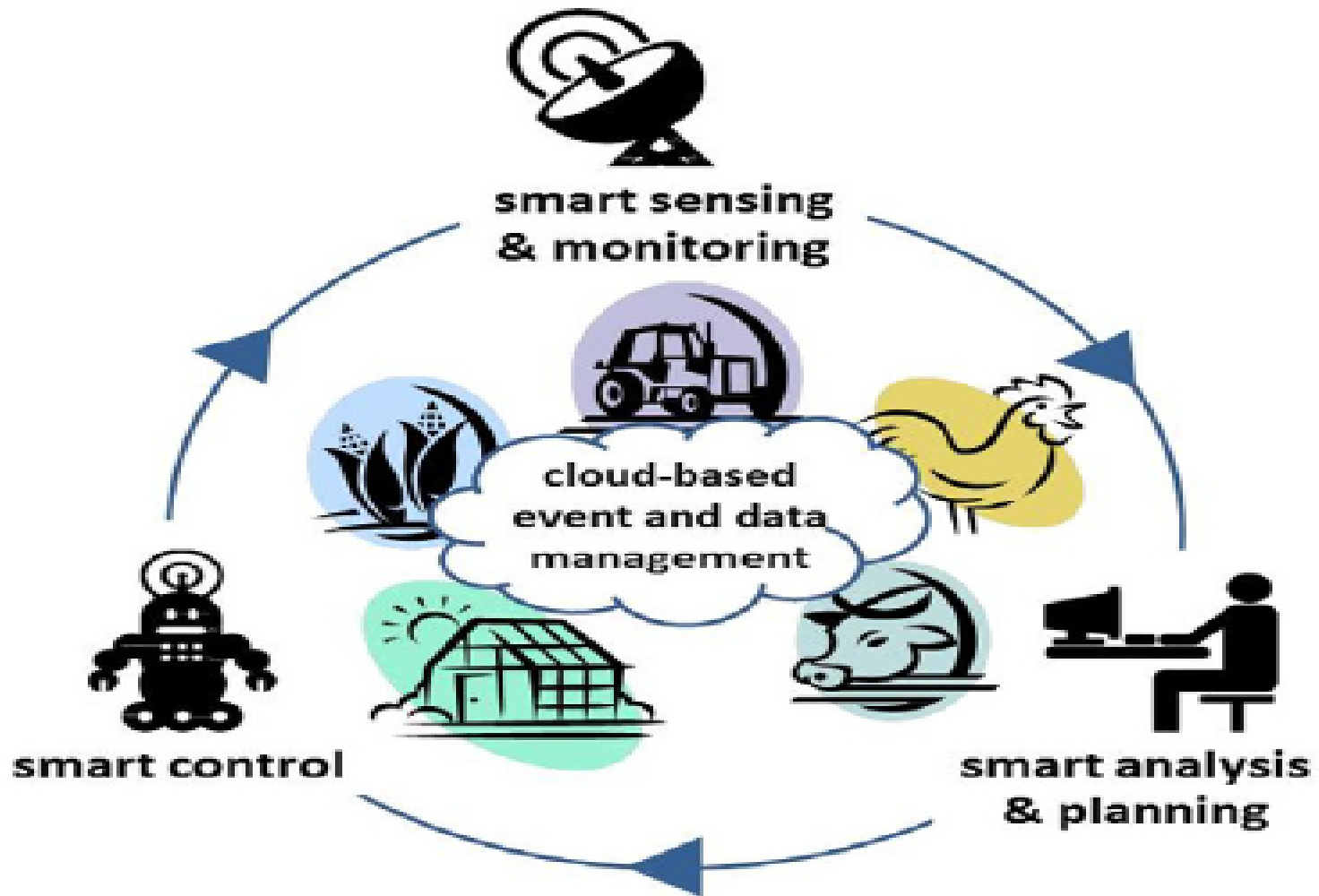


Fig. 1. The cyber-physical management cycle of Smart Farming enhanced by cloud-based event and data management (Wolfert et al., 2014).

Integrated Solutions

S. Wolfert et al. / Agricultural Systems 153 (2017) 69–80

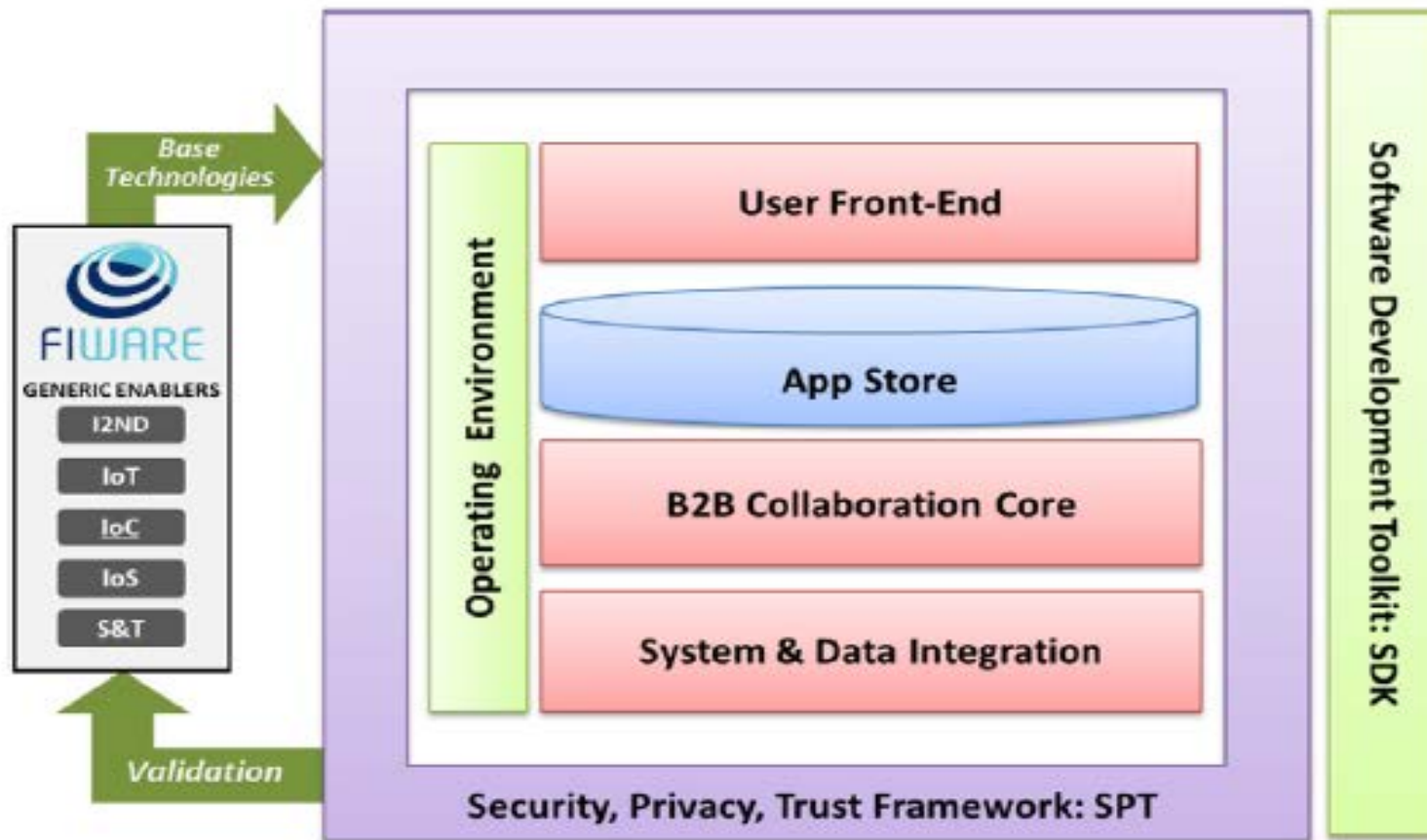
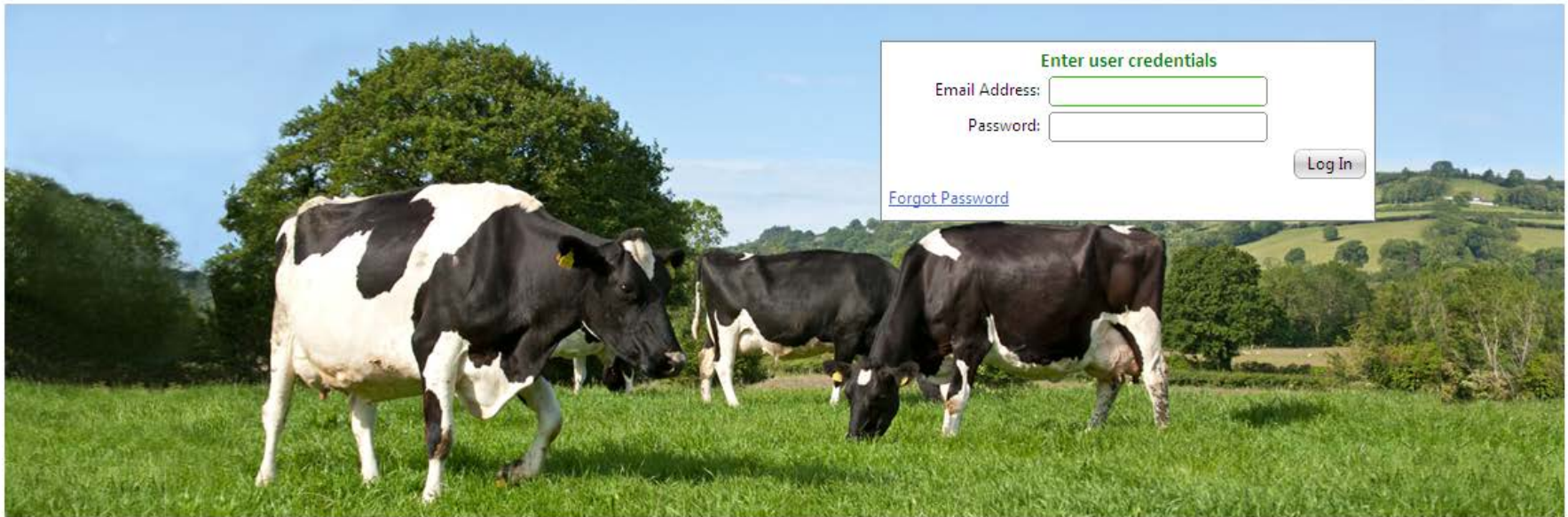


Fig. 6. A high-level picture of the FIspace architecture based on FIWARE GEs. Further explanation in text.

PastureBase Ireland- National Grassland Database



Research Programme



Precision Agriculture



SMART SUSTAINABLE PASTURE SYSTEMS