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Precision Livestock Farming (PLF) into Practice

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A favorable context for the development of PLF

- Evolution of structures
  - Increase in herd size
  - Increase in labor productivity
- Change in rearing conditions and increased surveillance
  - Increased risk of (nutritional) pathologies / infectious diseases
  - Animal welfare
- Change in the economic context – anticipation, adaptation
  - Price volatility
  - Flexibility of decisions
  - Traceability of livestock products throughout the food chain
- Explosion of ICTs = new powerful technologies
  - Data analysis methods (broadband, Artificial Intelligence, learning)
  - Advances of electronic systems (portable, autonomous, reactive)

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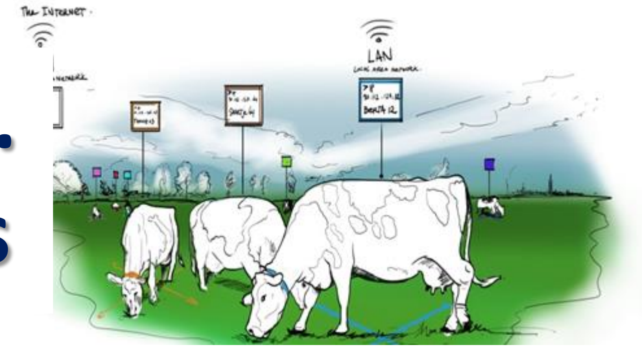
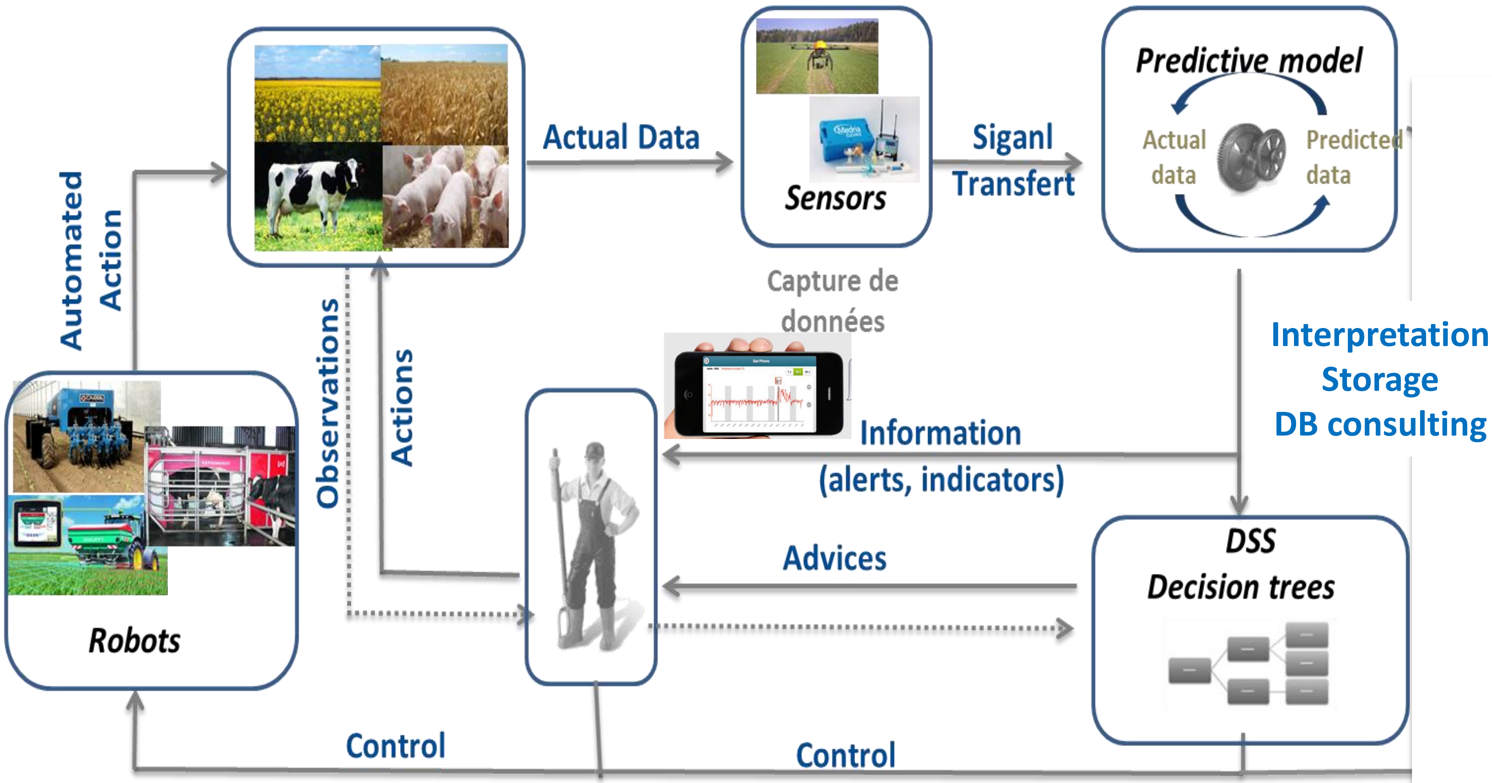
Precision Livestock Farming…
…stakes and promises



- **Efficiency:** More efficient use of resources and reduction of harmful emissions per unit of product (precision feeding)
- **Diagnosis:** Reduction of the use of drugs through early detection of pathologies, improvement of animal welfare
- **Prevention:** Management of environment in livestock housing
- **Workload:** Reduction of work load/pain through automation
- **Certification:** Traceability of modes of management and events (animal welfare, environment), control of product quality (sanitary, nutritive…)
- **Phenotyping:** High throughput phenotyping for selection on new characters (robustness) and deployment of genomic selection

Principles of Precision Livestock Farming?

What is Precision Livestock Farming?



Management of Livestock by continuous automated real-time monitoring of production, reproduction, health and welfare of livestock and environmental impact

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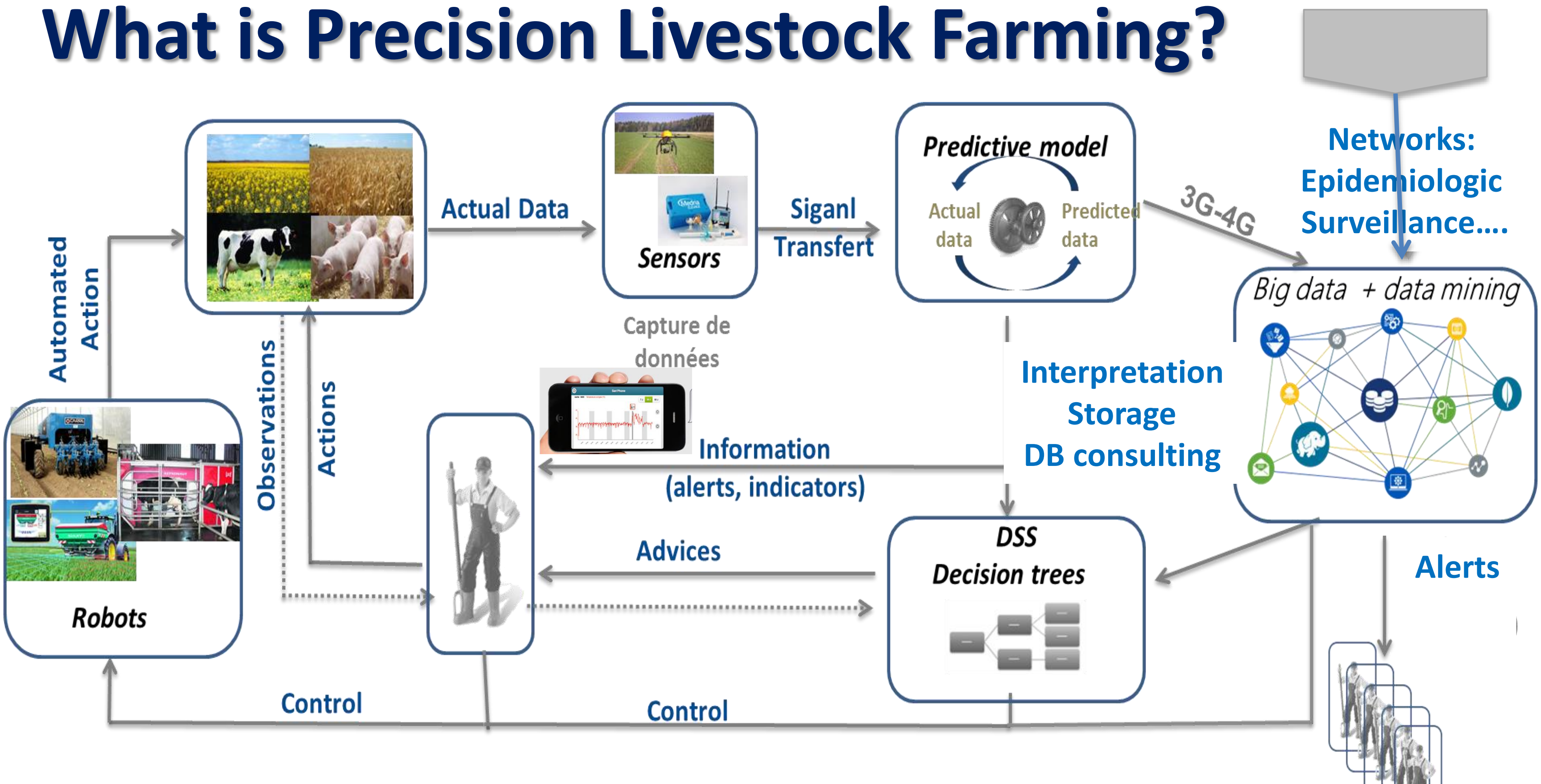

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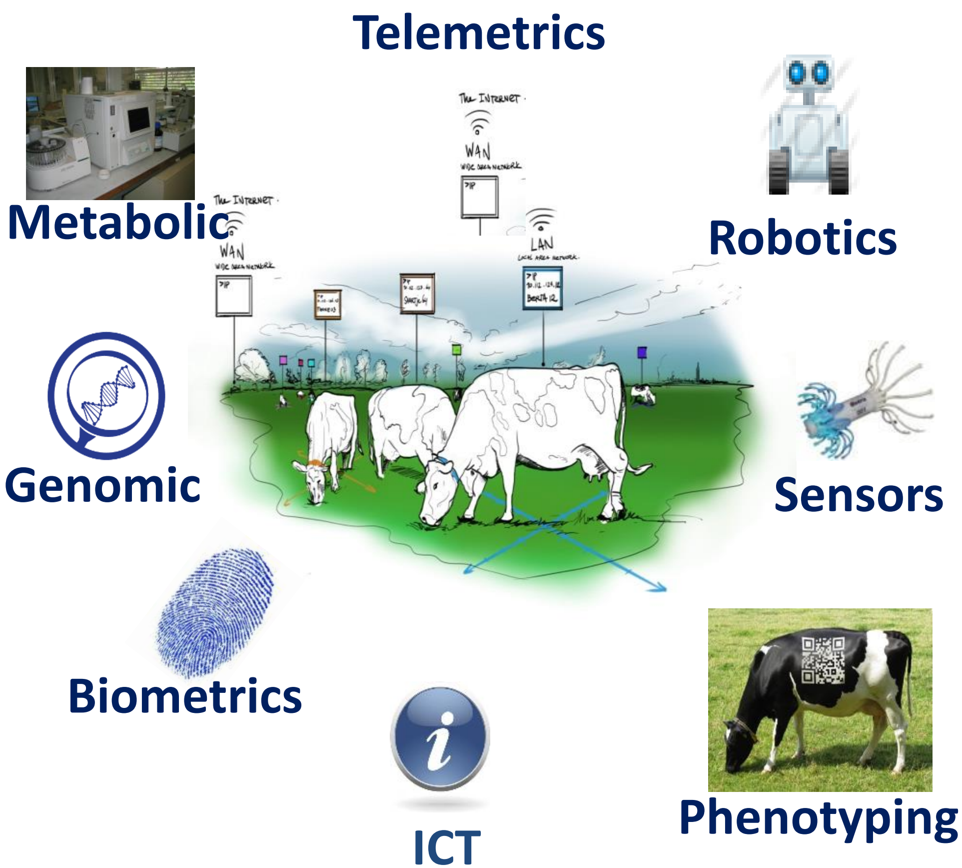
PLF associates numerous technologies



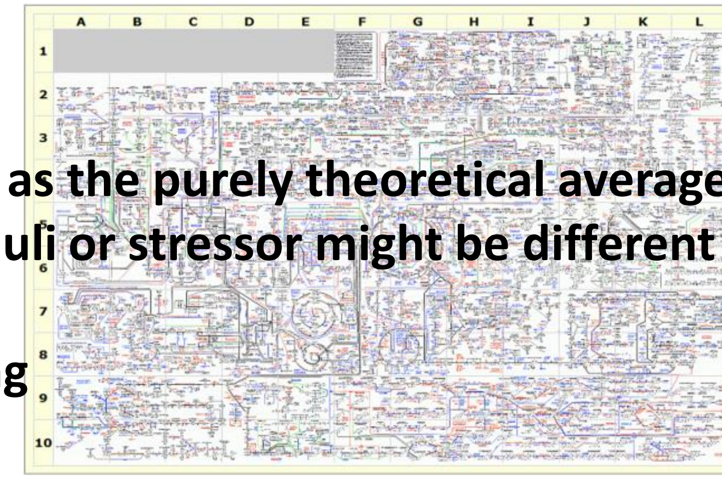
Sensors for real-time record of bio-signals

- On the animal
  - GPS position
  - Identification (RFID)
  - Accelerometers
  - Ph, temperature
  - …
- No need of physical contact
  - Sound
  - Imagery

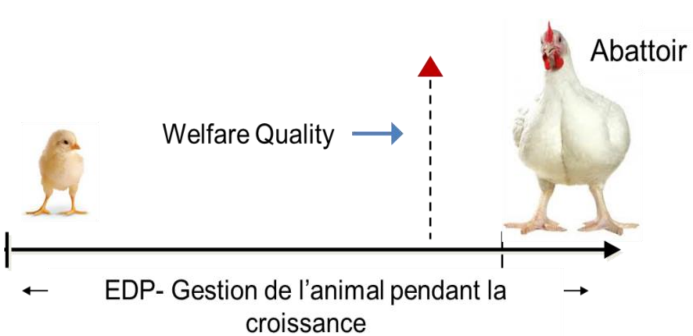
… to create value for the farmer…

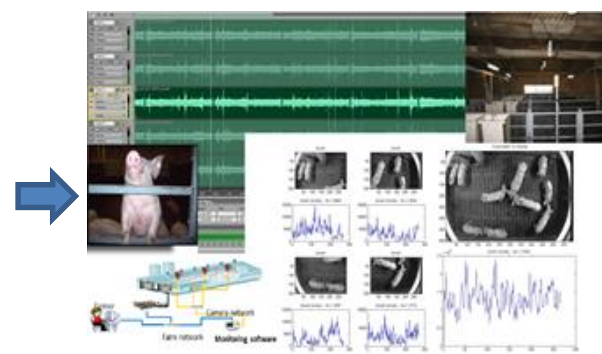
Why continuous automated real-time monitoring?

Berckmans and Aerts (2006)



- A living organism is
  - Complex
  - Unique: no single living organism lives/acts as the purely theoretical average
  - Time varying character – response to a stimuli or stressor might be different each time it happens
  - Dynamic : living organism evolves with aging
- What can new technologies do?



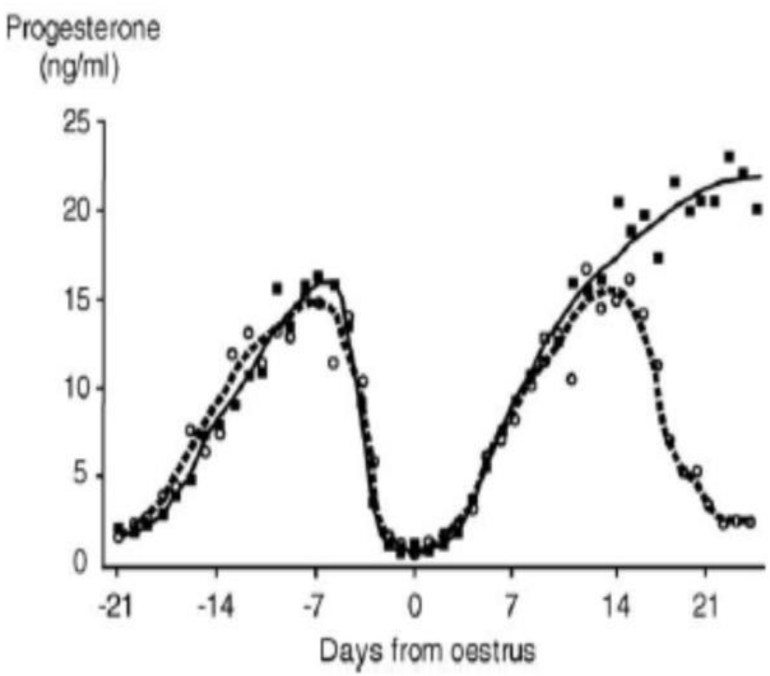


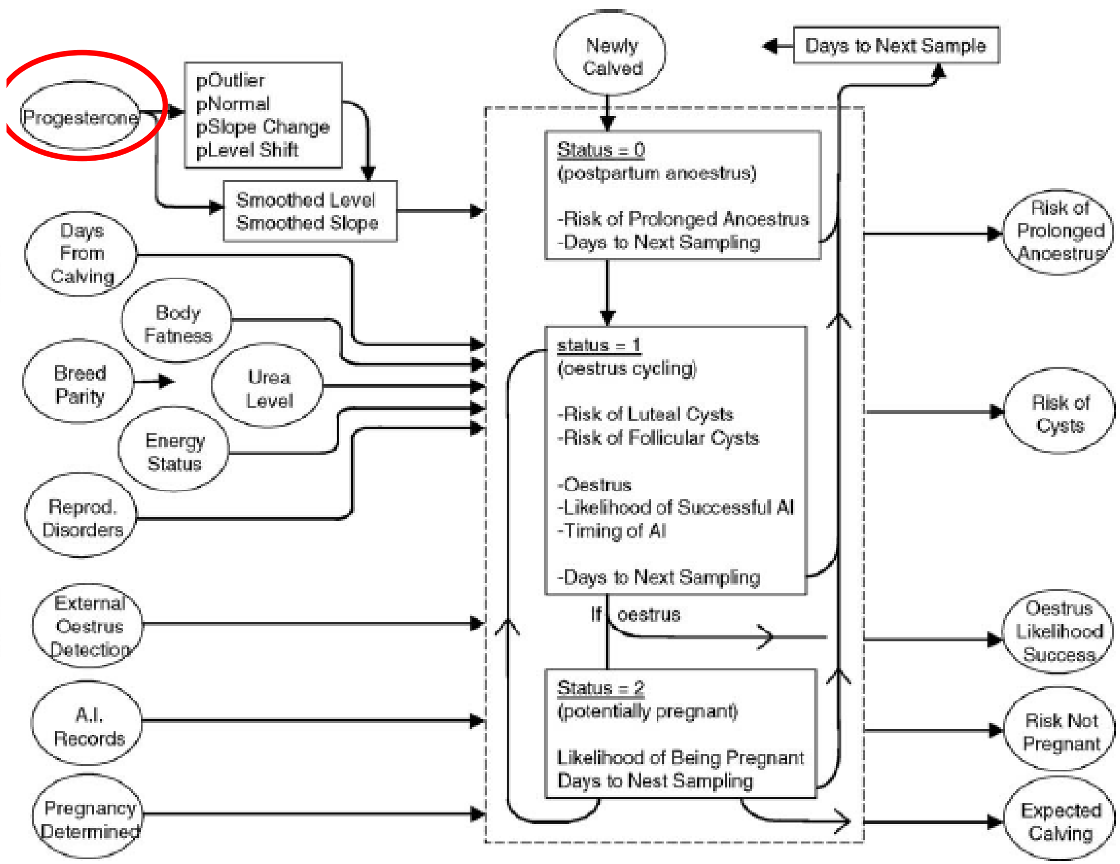
Framework for PLF tool development

Target variable	Trait ontology for a precise definition of the target variable (ex : how to define lameness or mastitis?)
Gold standard	A reliable reference measure of the target variable (ex : DMI from weighing system)
Feature variable	Another variable in relation to the dynamics of the target variable and calculated/measured from field measurements at a high sampling frequency
Labelling	Define a reference point that indicates the point in time when the feature variable shows a deviation from the normal gait (careful analysis, understand the biological meaning)
Algorithm	Detect the deviation from a healthy gait automatically, must enable calculation of the feature variable in real time

Adapted from Norton and Berckmans (2017)

Model the response to interpret the signal: ex progesterone





(Friggens and Chagunda (2005))

Some examples in pig, poultry and ruminant farms

Developping PLF

- Development of PLF is strongly pulled by the dairy sector
  - Dairy cow stay longer in production, compared with any other farmed animals
  - Each animal unit is of high economical value
  - Individual management
  - Availability of milk sample/biomarkers
  - Increasing robotics (milking robots appeared 20 years ago)
- PLF concept is rather new in the European pig industry
  - Early adopters start to use it
- PLF is well developed in the poultry industry

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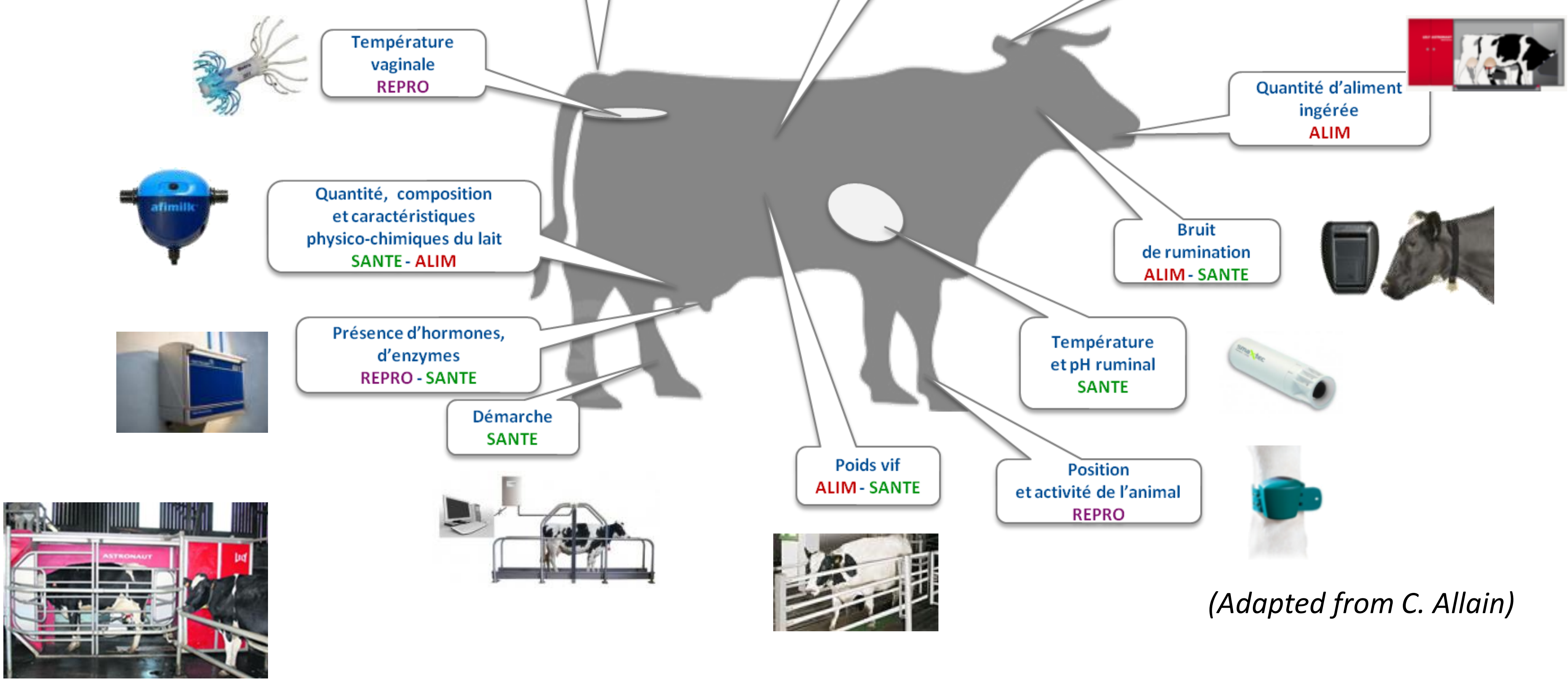
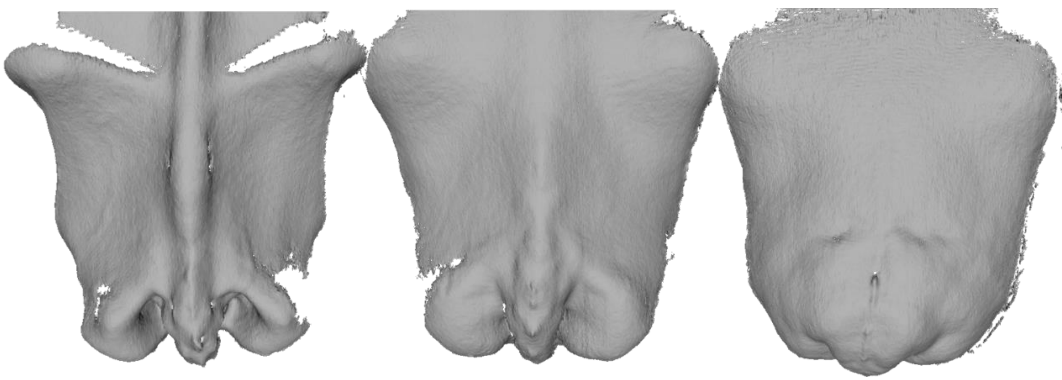
The connected cow

- *Biology / physiology*
- *Morphology*
- *Behaviour*
- *Environment*



(Adapted from C. Allain)

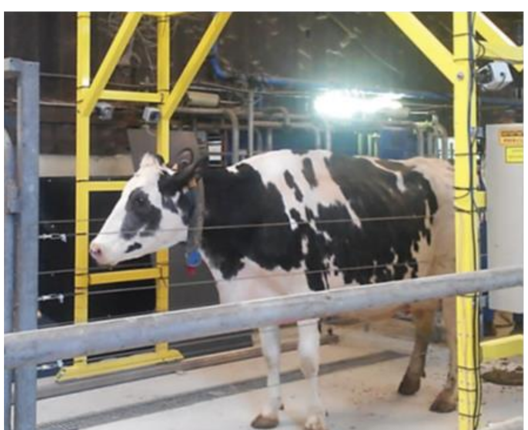
Notation of the body condition score by 3D imaging



NEC = 1 NEC = 3 NEC = 4.75

Body Condition Score

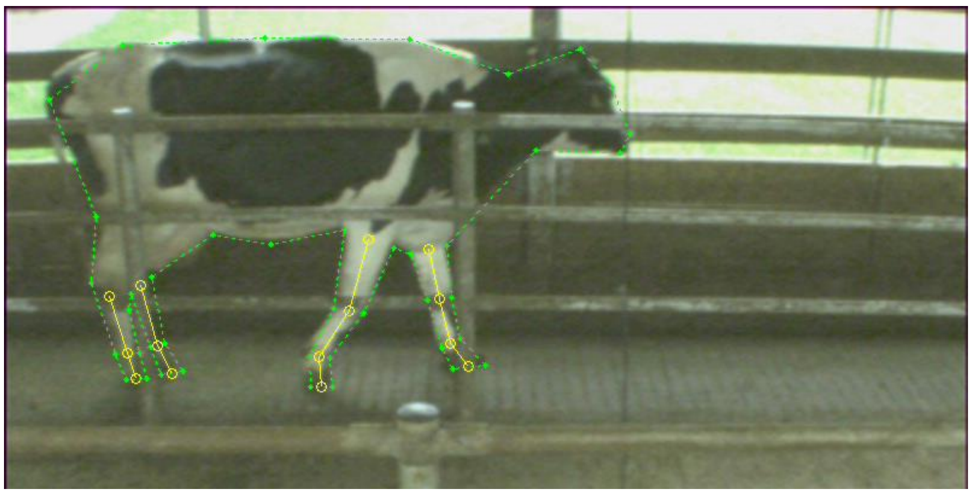
- automatic notation

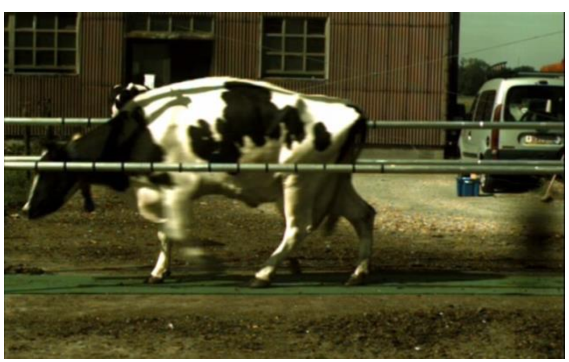


Morphology

- Mensurations
- Angularities
- Volume/area
- Carcass evaluation

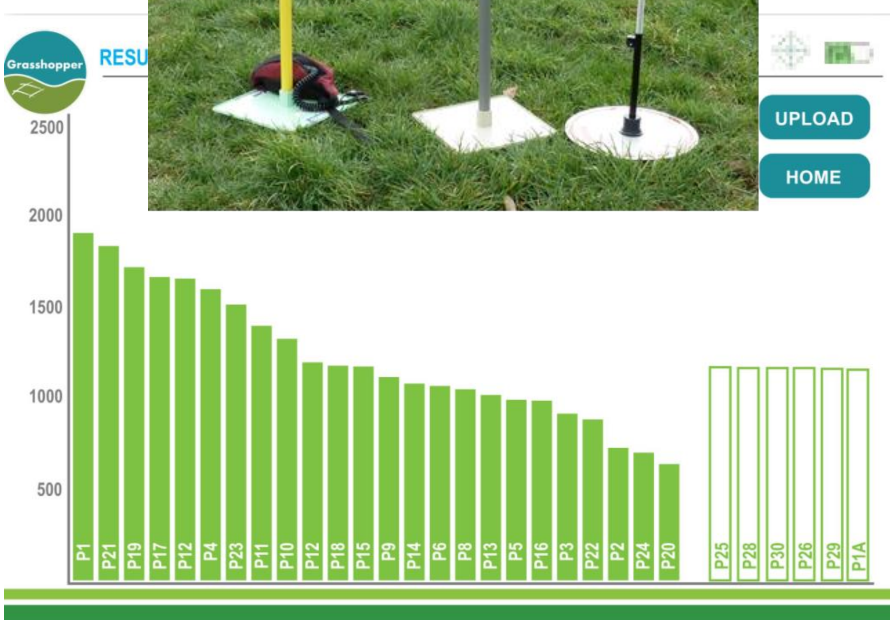
Real-time monitoring of lameness in dairy





- Overlapping steps
- Hooves lifting time
- Floor shoe contact time
- Duration of a cycle (one step/one leg)
- Length of step
- Arch of the back
- Angle of the leg when the hoof touches the ground

Connected tools for grazing management



Management of the resource

- Evaluate biomass and growth
- Integrate this information into tools to manage paddocks and decide on plot changes
- Evaluate the efficiency of herbage utilisation

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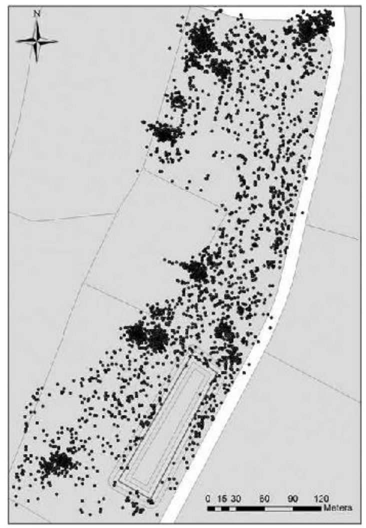
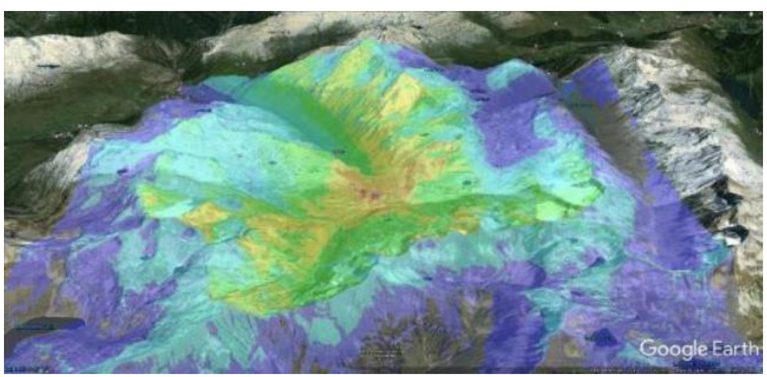
Ruminant to manage large natural areas





Collecting knowledge on the diversity of the environment

- remote sensing (satellites, drones)
- mapping of the state of resources and biodiversity

Collecting knowledge on the animal and its location

- Geolocation
- LORA communication
- Virtual fence
- Alarm, predator, robbery
- Activity, stress

Precision feeding for dairy cows and pigs

Knowledge on individual characteristics

⇓

Use of an efficiency steering function

⇓

Modification of the individual ration

⇓

Increased efficiency

Feeding each cow with a ration whose protein content is adjusted to maximize protein efficiency vs. feed in the entire herd with a balanced diet for the average animal

Protein suply	Const.	Var.
Metabolisable protein efficiency (%)	59.3	69.1
SBM / milk protein (kg DM/kg Prot)	3.06	1.73

Feeding a group of pigs with a 3 phases strategy or a multi phase strategy or a multiphase strategy with individual adjustment

	3 phases	Multi phases	MP + individual
Live weight gain (g/d)	1105	1105	1100
N balance (g/d)	73	65	62

Water intake monitoring in pig and poultry farming

- Water meter is one of the simplest tools that farmers can use to monitor the performances of the animals
- Difference between expected and measured water intake
  - A early sign for health problem
  - A sign of leakage (wetting litter)
- Can help to apply adequate vaccination strategies
  - Vaccines distributed over drinking water

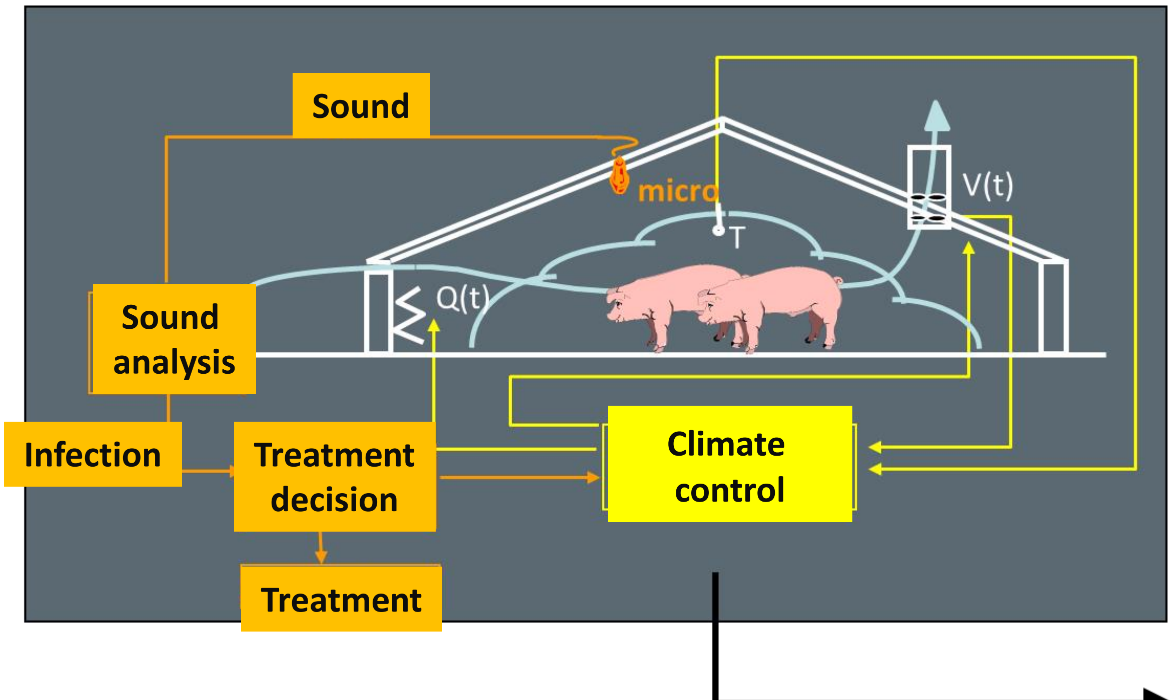
Automated weight detection by video image analysis in pig farming

Several commercial systems have been introduced to monitor

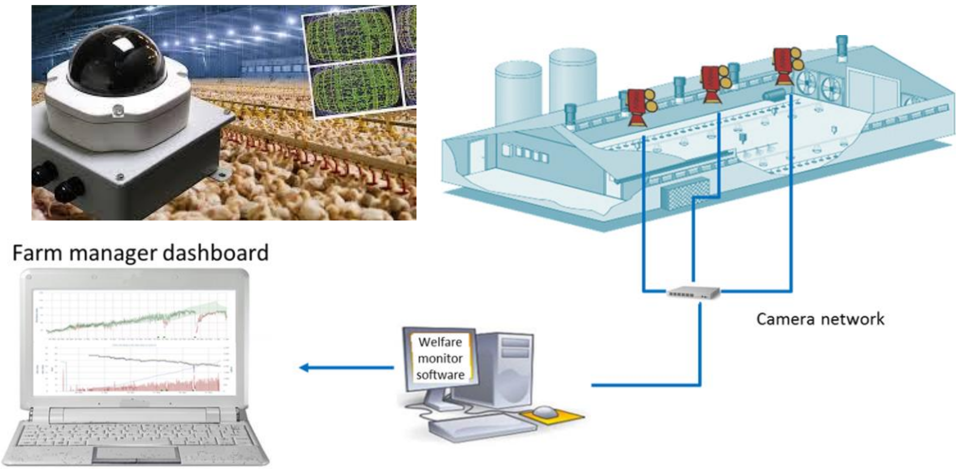
- **Activity level**
- **Occupation density in the pig pen**
- **and creating alerts by changes in animal behavior**

Vranken and Berckmans (2017)

Automated detection of repiratory infections by cough continuous monitoring



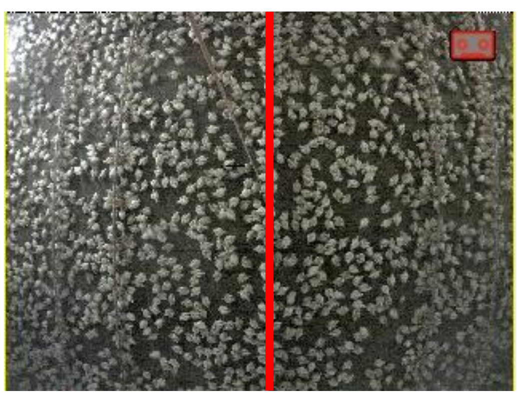
Early warning system for broilers houses



eYeNamic system

Detection of most of the daily problems by analyzing the broilers' behavior

- **Problem in feeding system**
- **Problem in water supply**
- **Electricity failure**
- **Light problems**
- **Climate control**
- **Etc.**



Feeder line: normal situation

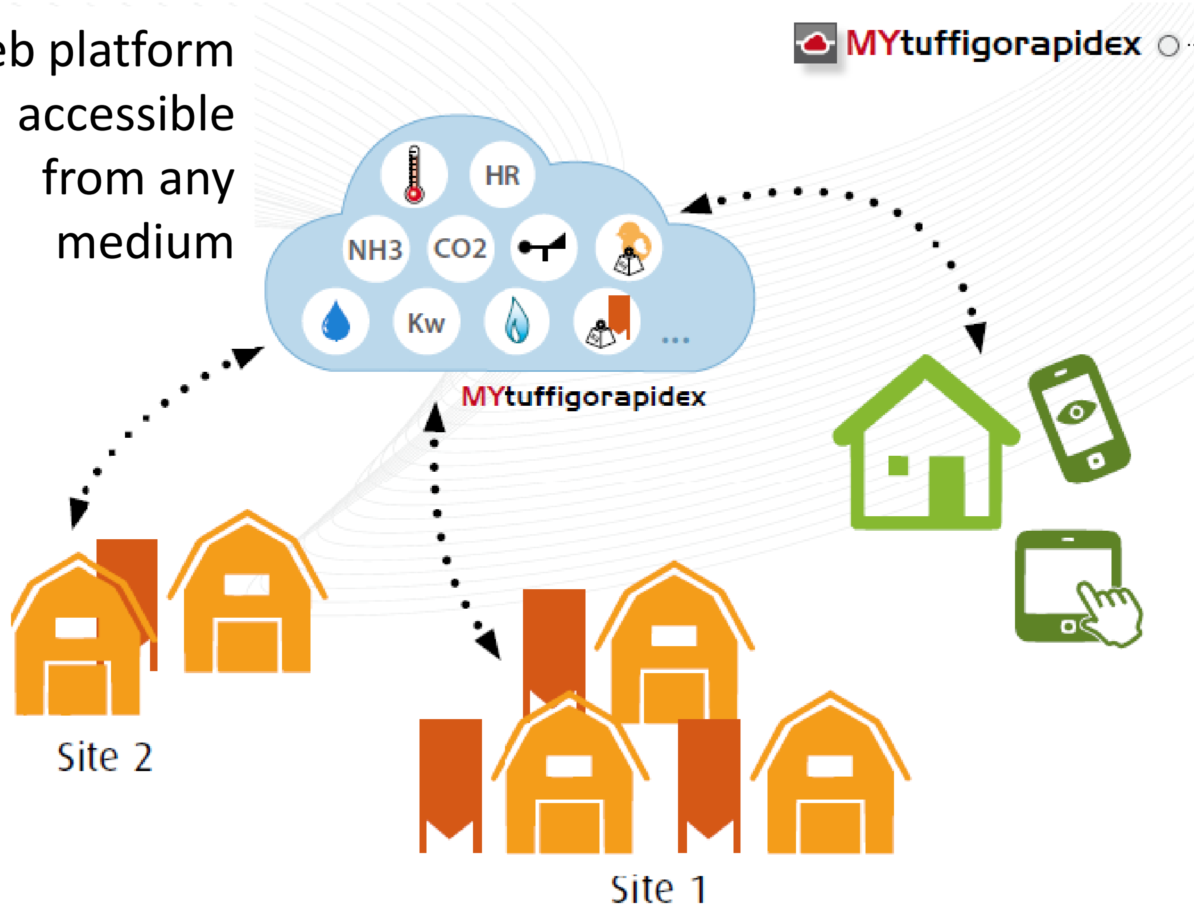
Defect Feeder line

Berckmans (2017)

EU - PLF

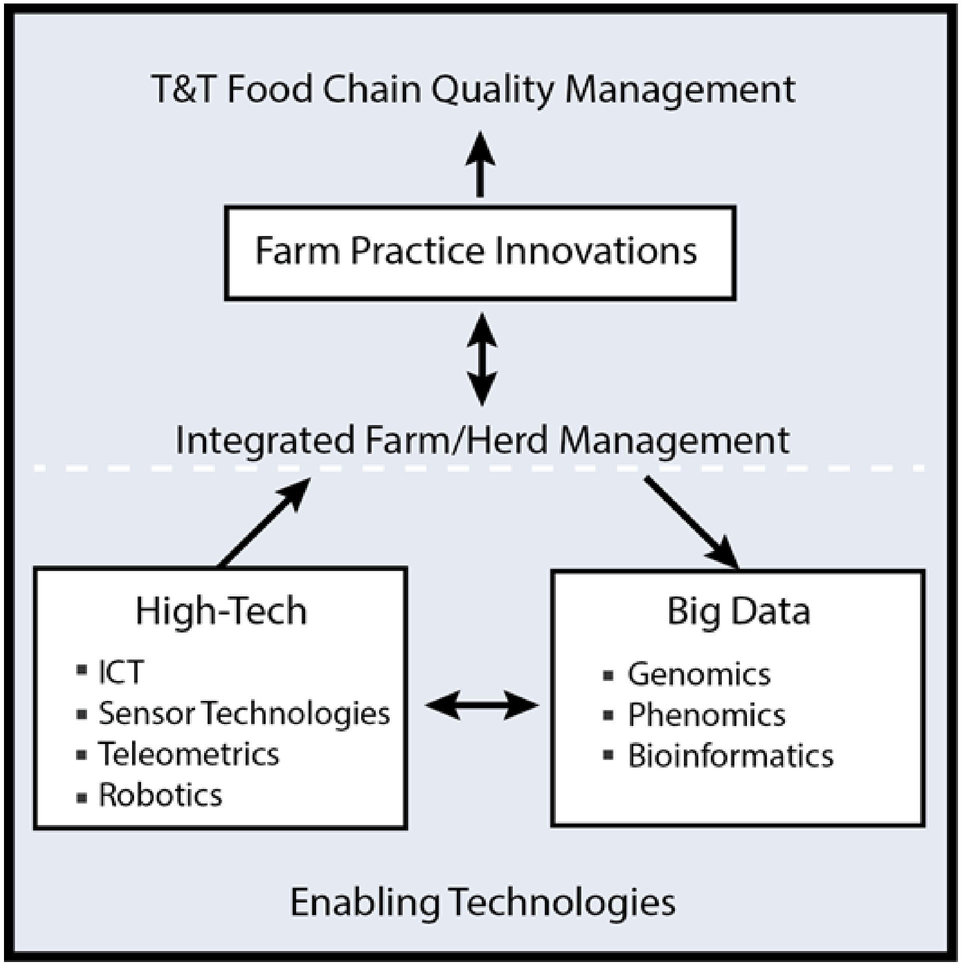
Implementation of PLF at territory level

Web platform accessible from any medium



Collection of information between several farms allowing a territorial optimisation

Implementation of PLF at food chain level



Farmers expectations

Low adoption rate of the new technologies

Survey on the barriers to the adoption of new monitoring technologies in dairy farming (229 dairy farmers in Kentucky, US) (Russel and Bewley, 2013)

Reasons for a low adoption rate	%
Not familiar with available technologies	55
Unattractive cost / benefit ratio	42
Too much information provided without knowing what to do	36
Not enough time to spend with these technologies	31
Not convinced by the economic interest	30
Too difficult or too complicated to use	29
Weak technical training/support	28

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ATF Vision: some messages for a successful development of PLF

Very attracting new technologies but…

- Information that in itself is not always useful or usable
  - Too much information kills the decision!
  - Risk of inappropriate treatments with too early detection
- Tools are still too focused on information (production of alerts) and not enough on the control of the systems
  - Still few tools to better use the potential of this information
- Very specialized information
  - One device = one information
  - Few information for herd management
- Often captive systems
  - Scalability? Compatibility? Interconnections? Lifespan?
  - Data exchange with information system?
- A further risk to favor intensive systems ? (P. Stevenson, ECPLF 2017)

A future of PLF still largely to be built

- The biological knowledge and the technological possibilities will offer new perspectives and new indicators for PLF
- Information management will play a decisive role
  - Information system will be the heart of the device
  - Open and evolving IS to make the best use of information (IoT)
- The couple "information + robotisation" will offer innovative perspectives in research and husbandry
- The importance of modelling to give value to the information
- Consumers and society will benefit from the use of PLF as it will allow them to be informed on the welfare and health of the animals

Technical challenges

- Sensors, data acquisition and treatment
  - Development of Bio/smart sensors
  - Dynamic multi-criteria approaches (MIMO), Self learning?
  - Precision buildings, source of new features (robotics, climate regul)
- Mechanistic whole animal models
  - Interpretation of data and signals from sensors
  - Integration of models into DSS that remain to be developed
- More generic and interconnected Information systems
  - IoT to facilitate machine-processor communication (+ crowd sourcing, web)
  - Standardised exchange format
  - Make data retrievable, accessible, interoperable and re-usable
  - Innovative management tools for big data and cyber security

Technical challenges

- Integrate genomic information into precision breeding
- Valuing the potentialities of big data for animal breeding
  - Development of animal phenotyping: integration of "omics" data and data from sensors
  - Access to new characters of interest

Societal challenges

- Digital tools must be adapted to the need of end-users (farmers)
  - Co innovations between researchers, farmers & stakeholders
  - Training farmers are essential to ensure clear benefits
- Analyse the consequences on the farmer’s job
  - Relationships with animals and with machines
  - Work organisation and new activities (maintenance of devices…)
  - Ergonomic of the insertion of the tools into the farm
- Take into account geographic, socio-economic and farming systems variability across Europe
  - Need for Increase efficiency and/or collaborative digital tools
- Consider the societal acceptance of these new technologies
- Legal issue of intellectual properties
  - New business model for open data management and use

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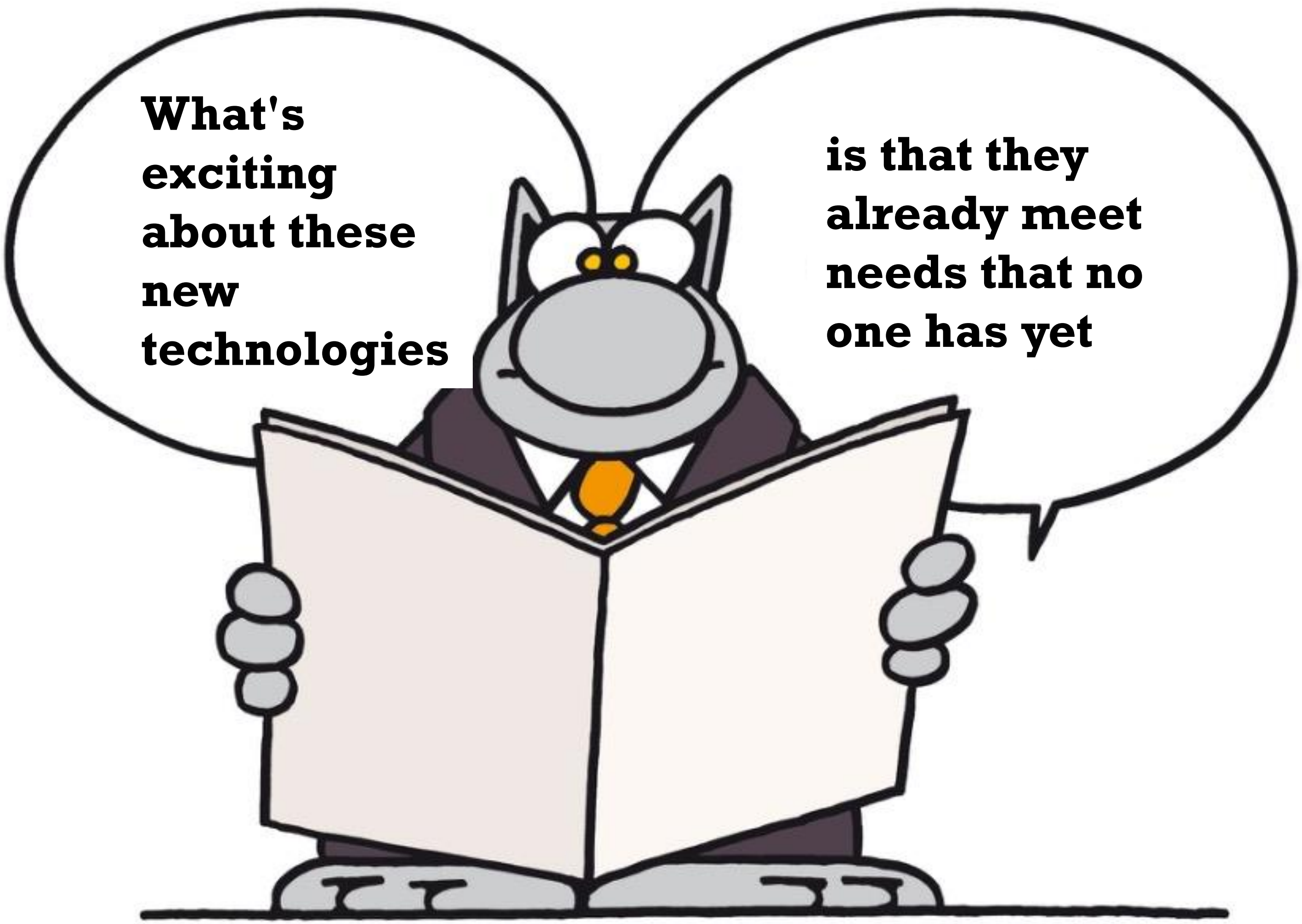
Conditions of success: create value for farmers

- The added value for farmers (advisory services, food chain) should be tested, validated and demonstrated in practice
  - The utility of many systems is not demonstrated
  - Need demonstration in farm, modelling, training
  - Development of appropriate tools for costs-benefits analysis
- Solutions need to be integrated into farm management systems
  - Multi inputs – multi outputs systems, inter operability


What's exciting about these new technologies
is that they already meet needs that no one has yet