

TrackLab 2: Automatic recording and analysis of the behavior of animals kept in groups



Lucas Noldus
Wijnand Ouweltjes
Bas Rodenburg
Kathalijne Visser
Ben Loke
Arno van Gijssel

EAAP 2019
Ghent, Belgium
28 August 2019

NOLDUS INFORMATION TECHNOLOGY



- Developer of software, hardware and integrated solutions for measurement and analysis of animal behavior, health and welfare
- Founded in 1989 (spin-off from Wageningen University)
- Headquarters in Wageningen, The Netherlands, offices in 9 countries
- 165 employees
- > 10,000 customers
- Clients: universities, research institutes, corporate R&D departments



INDIVIDUAL BEHAVIOR OF GROUP-HOUSED ANIMALS

Trends

- Farm animals are increasingly kept in groups
- Farms are becoming larger
- Adoption of Precision Livestock Farming methods

Needed

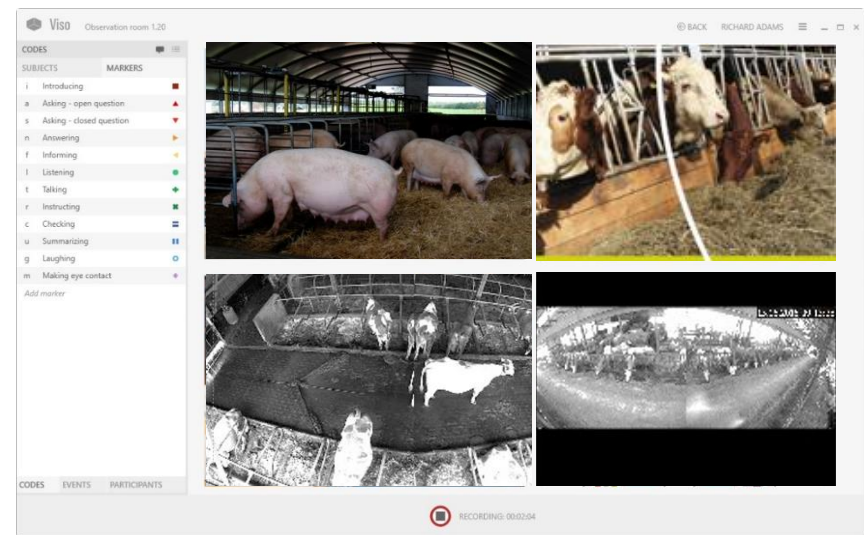
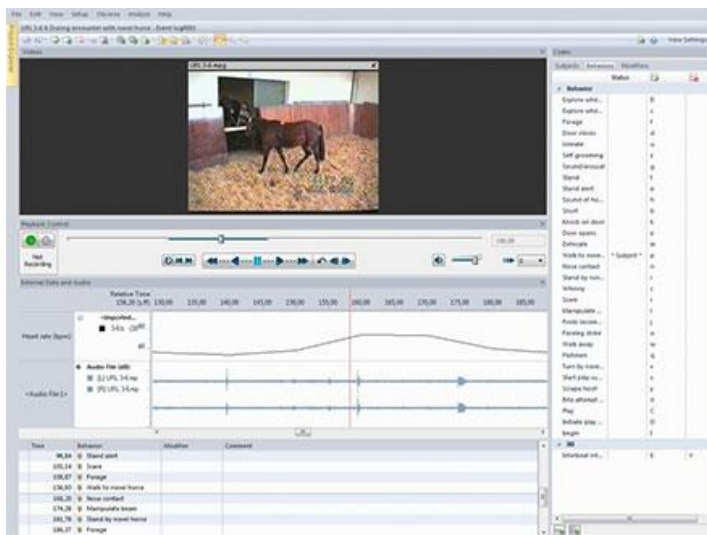
- We should be able to monitor the behavior, performance and welfare of **individual animals** housed in (large) groups



OBSERVATION AND SCORING OF BEHAVIOR

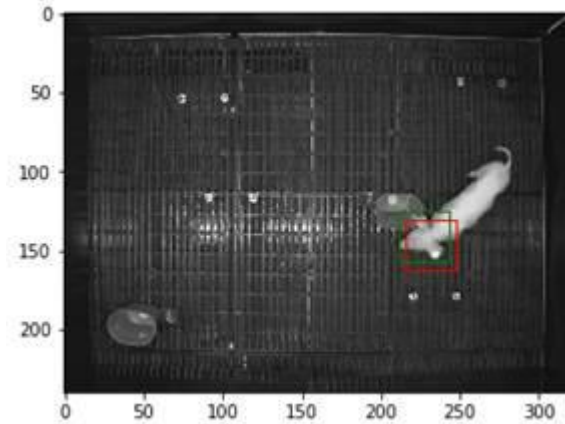
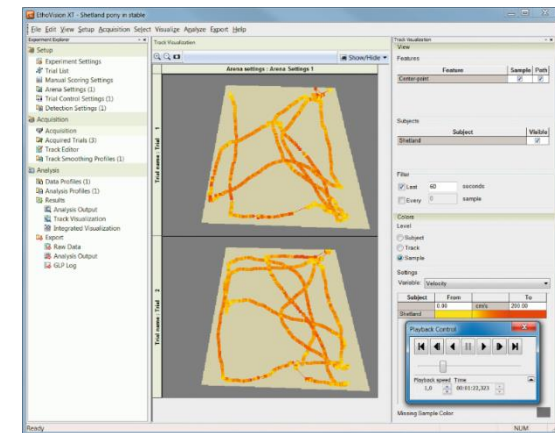
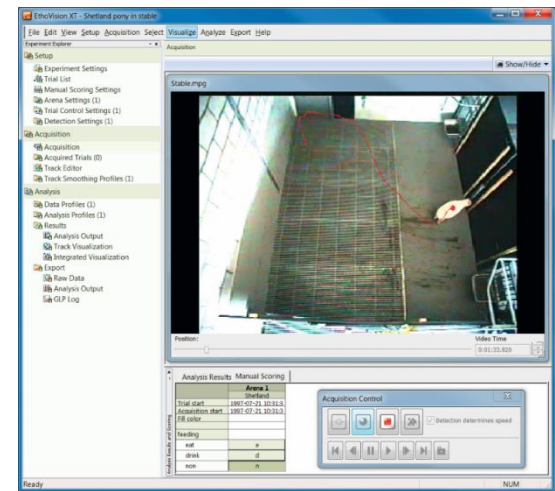


- Observation and manual event logging by human observer, live or from video
- Very flexible, from simple to complex ethograms, fine-grained analysis
- **But:** time-consuming, subjective, error-prone



VIDEO TRACKING

- Automated measurement of activity, locomotion, spatial behavior, presence in zones, interaction with other animals
- High spatial accuracy
- High temporal resolution
- Automatic behavior recognition using AI
- Identification based on body size or color
- Works well in small arena (pen, box), with small numbers of animals, and homogeneous light



VIDEO TRACKING

- Automated measurement of activity, locomotion, spatial behavior, presence in zones, interaction with other animals
- High spatial accuracy
- High temporal resolution
- Automatic behavior recognition using AI
- Identification based on body size or color
- Works well in small arena (pen, box), with small numbers of animals, and homogeneous light

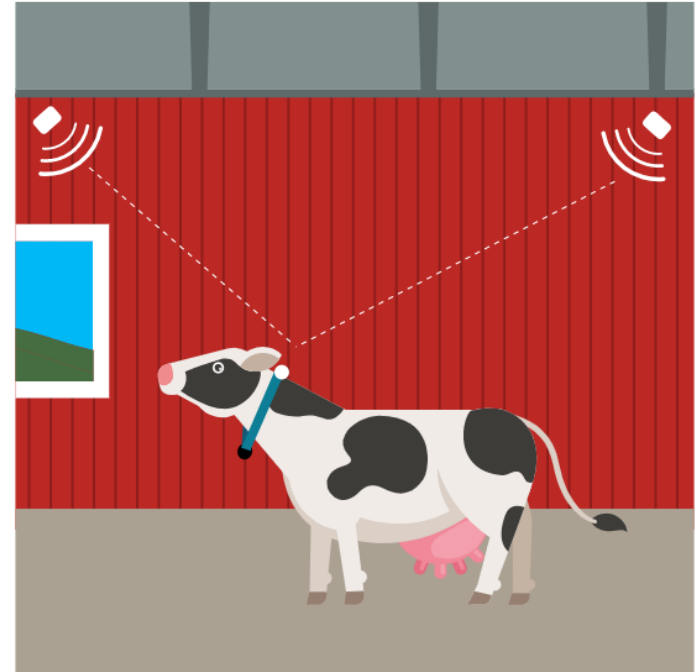
Dependent Variables	
	Add
Movement	
Distance moved	<input type="checkbox"/>
Velocity	<input type="checkbox"/>
Movement	<input type="checkbox"/>
Acceleration	<input type="checkbox"/>
Acceleration state	<input type="checkbox"/>
Location	
In zone	<input type="checkbox"/>
Distance to zone	<input type="checkbox"/>
Distance to point	<input type="checkbox"/>
Path	
Meander	<input type="checkbox"/>
Target visits and errors	<input type="checkbox"/>
Zone alternation	<input type="checkbox"/>
Zone transition	<input type="checkbox"/>
Direction	
Heading	<input type="checkbox"/>
Heading to point	<input type="checkbox"/>
Turn angle	<input type="checkbox"/>
Angular velocity	<input type="checkbox"/>
Body	
Activity	<input type="checkbox"/>
Activity state	<input type="checkbox"/>
Mobility	<input type="checkbox"/>
Mobility state	<input type="checkbox"/>
Rotation	<input type="checkbox"/>
Trial Control	
Trial Control event	<input type="checkbox"/>
Trial Control state	<input type="checkbox"/>
Custom Variables	
Free interval	<input type="checkbox"/>
Multi condition	<input type="checkbox"/>

LIMITATIONS OF VIDEO TRACKING

- Does not work with large numbers of similarly looking animals (identification)
- Does not work in large spaces (perspective distortion, occlusion)
- Does not work under variable light conditions
- Does not work well with changing backgrounds
- Beyond body center tracking: each animal species requires a different shape model

ULTRA WIDEBAND TRACKING

- Animal positioning based on ultra wideband (UWB) radio communication between tag (on animal) and sensors (mounted on wall or ceiling)
- Tags on collar, ear tag or backpack
- UWB tracking: accurate (30 cm), reliable, scalable
- Can be extended with other sensor technologies
- For animal studies in large indoor spaces or outdoor enclosures (e.g. feedlot)
- For tracking of one to many animals (with identification)



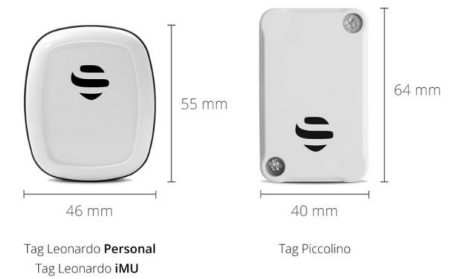
Ultra-wideband tracking hardware



Sensor mounted to wall



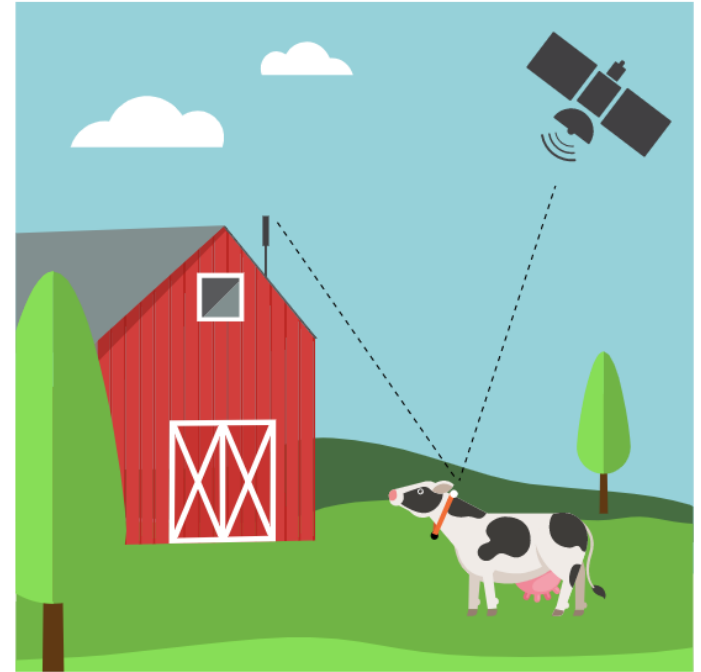
Backpack for chicken



Tag attached to animal

GPS TRACKING

- Animal positioning based on GPS sensing, followed by LoRa data transmission
- Tag on collar or ear tag
- Spatial accuracy approx. 2.5 m
- Can be extended with other sensor technologies
- For animal studies in large outdoor spaces
- For tracking of one to many animals (with identification)



GPS tracking hardware



GPS collars with battery or solar panel



LoRa gateway (10 km range)

SOFTWARE: OUR AMBITION

Needed

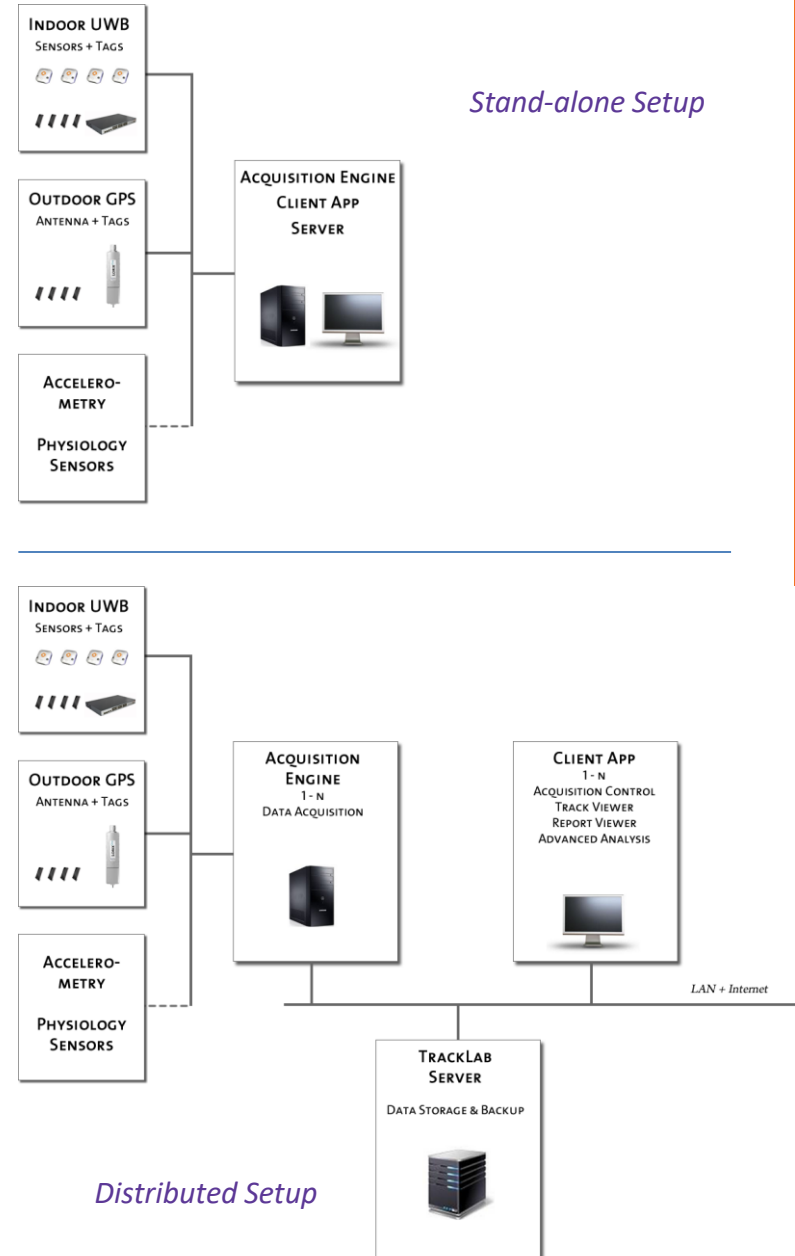
- Software package for experiment design, data acquisition, storage, visualization and analysis
- Sensors + data processing hardware + software = seamlessly integrated end-to-end solution for livestock research and R&D in the livestock industry

Requirements

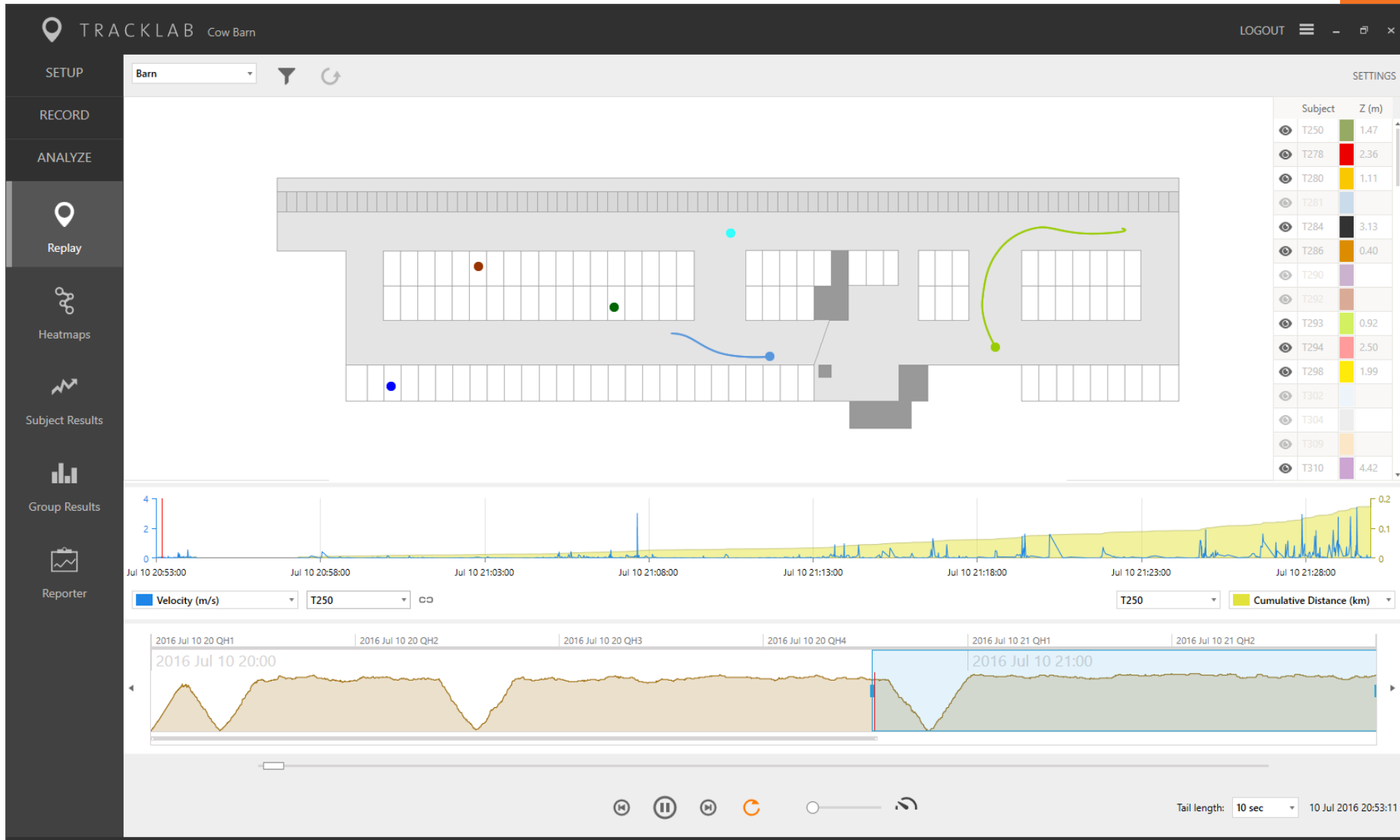
- Stand-alone (single computer) or distributed setup (network)
- Scalable: multiple animals, multiple locations, multiple users
- Multi-sensor support (UWB, GPS, 3D accelerometer, gyroscope, magnetometer)
- Researcher-centered design: white box, open I/O
- User friendly interface

TRACKLAB 2.0 SYSTEM ARCHITECTURE

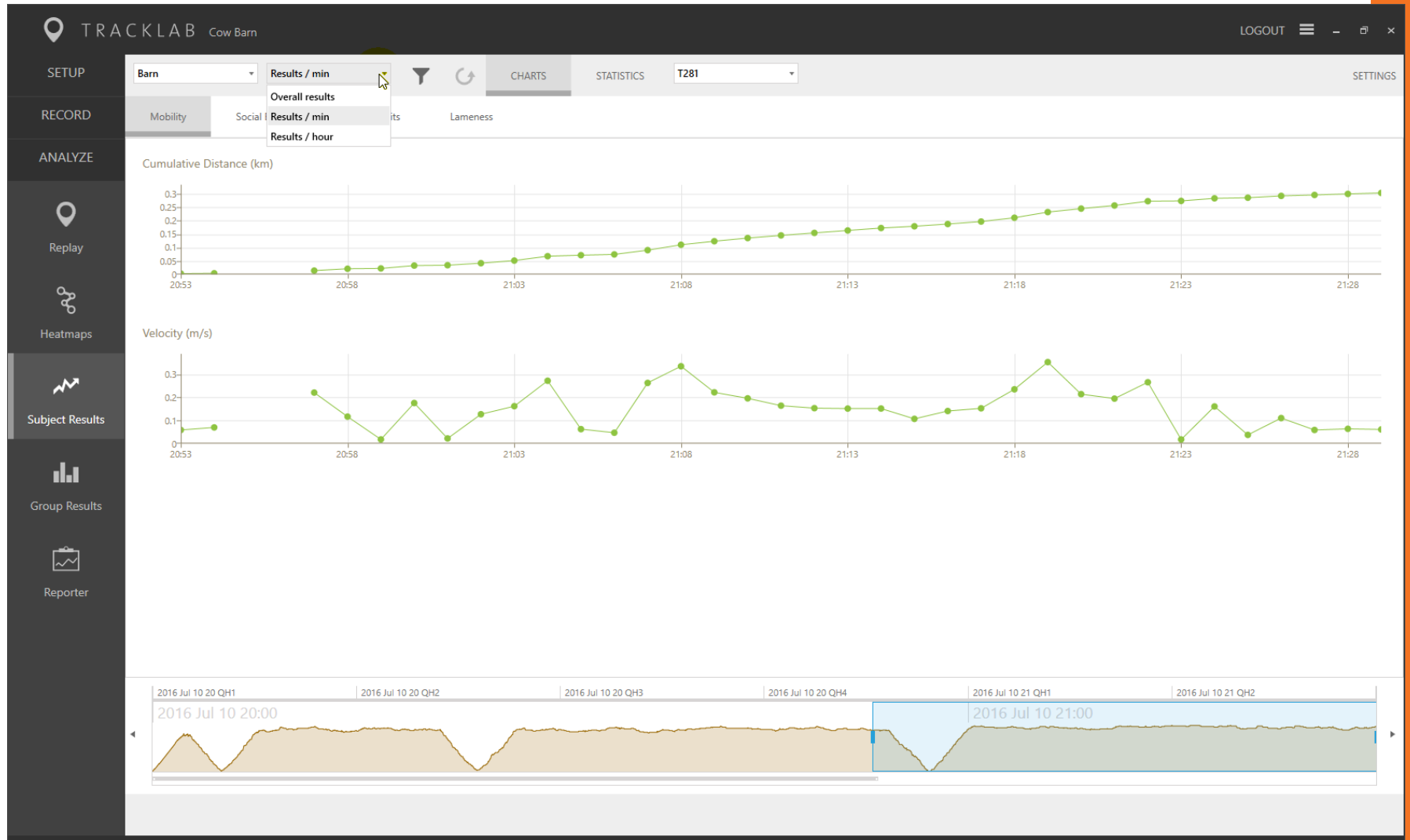
- Stand-alone or distributed setup
- Distributed setup:
 - Measure in the barn
 - Store and process data on the server
 - Analyze at your desk
- Scalable setup:
 - Multiple barns
 - Multiple software users
 - Central data storage



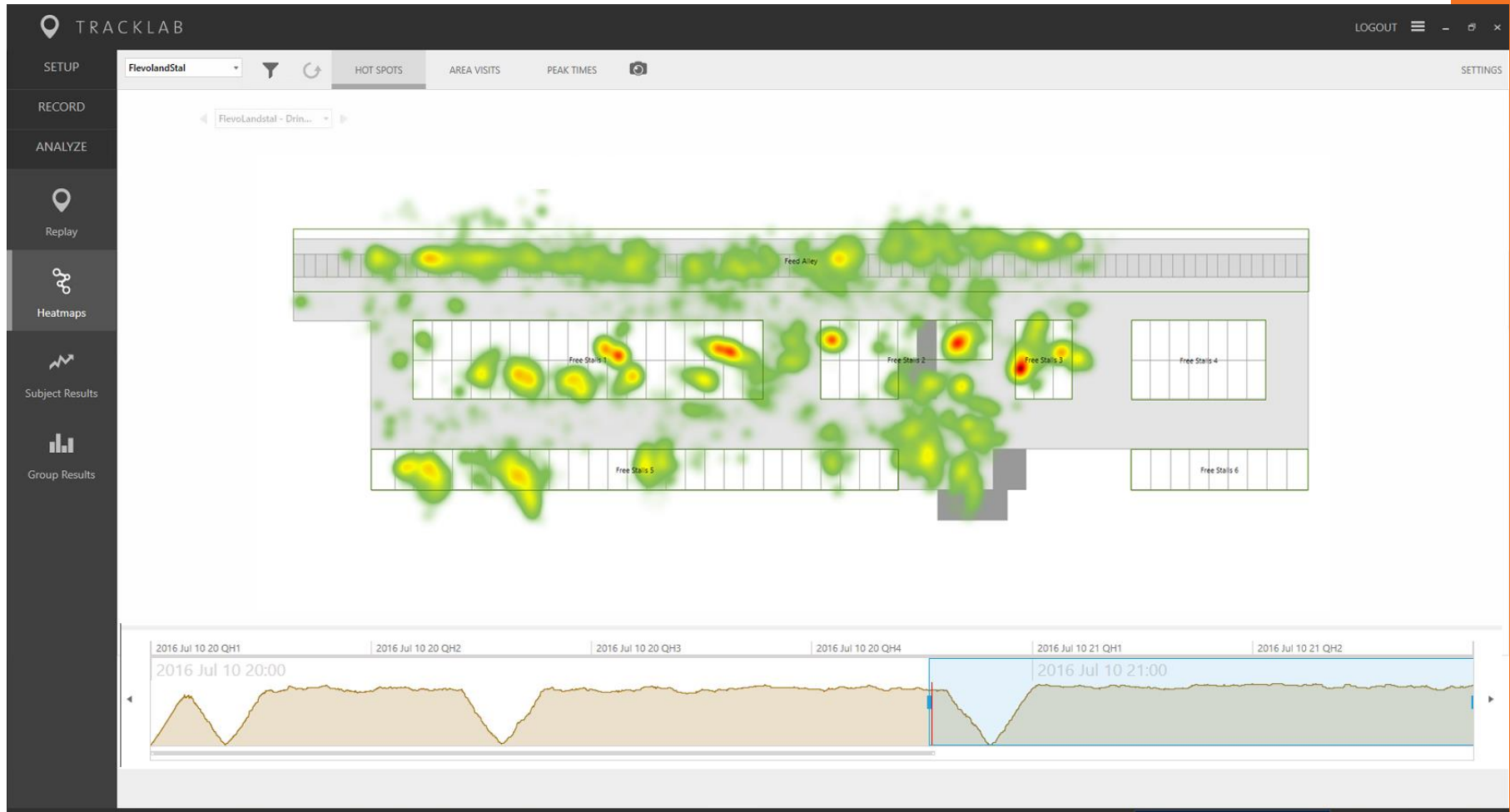
TrackLab: Data replay



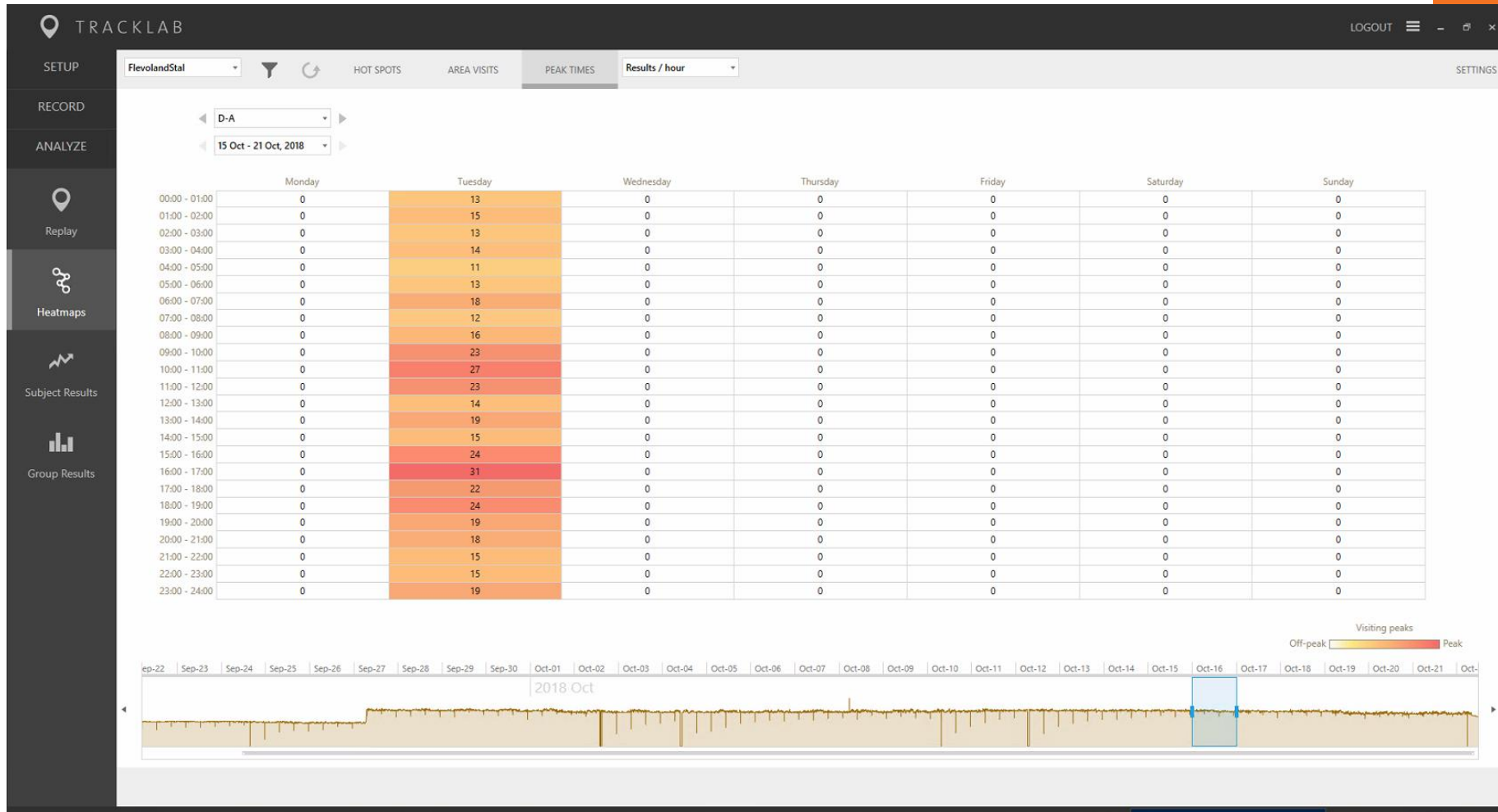
TrackLab: Statistics per user-selectable timebin



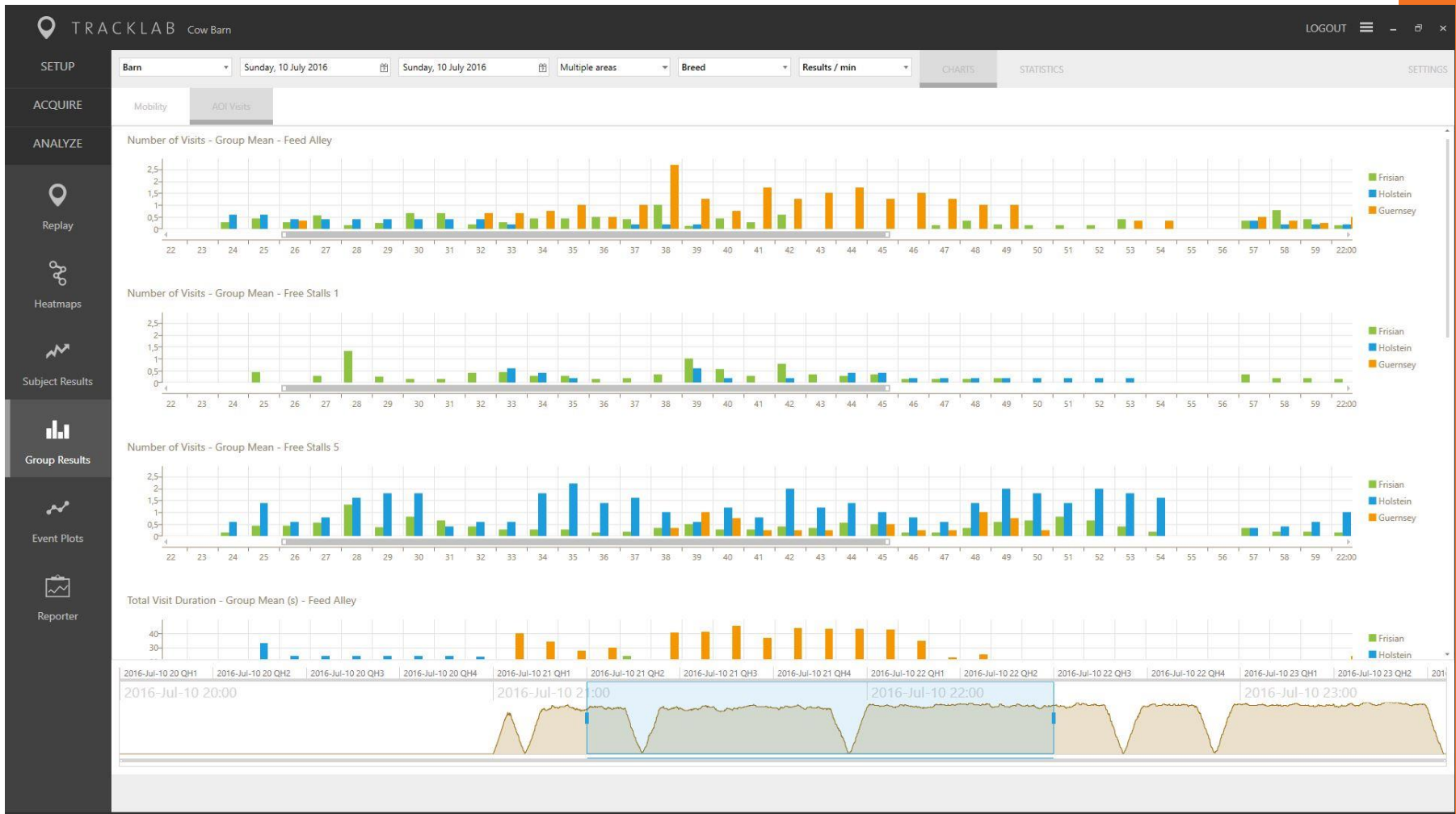
TrackLab: Qualitative heatmap



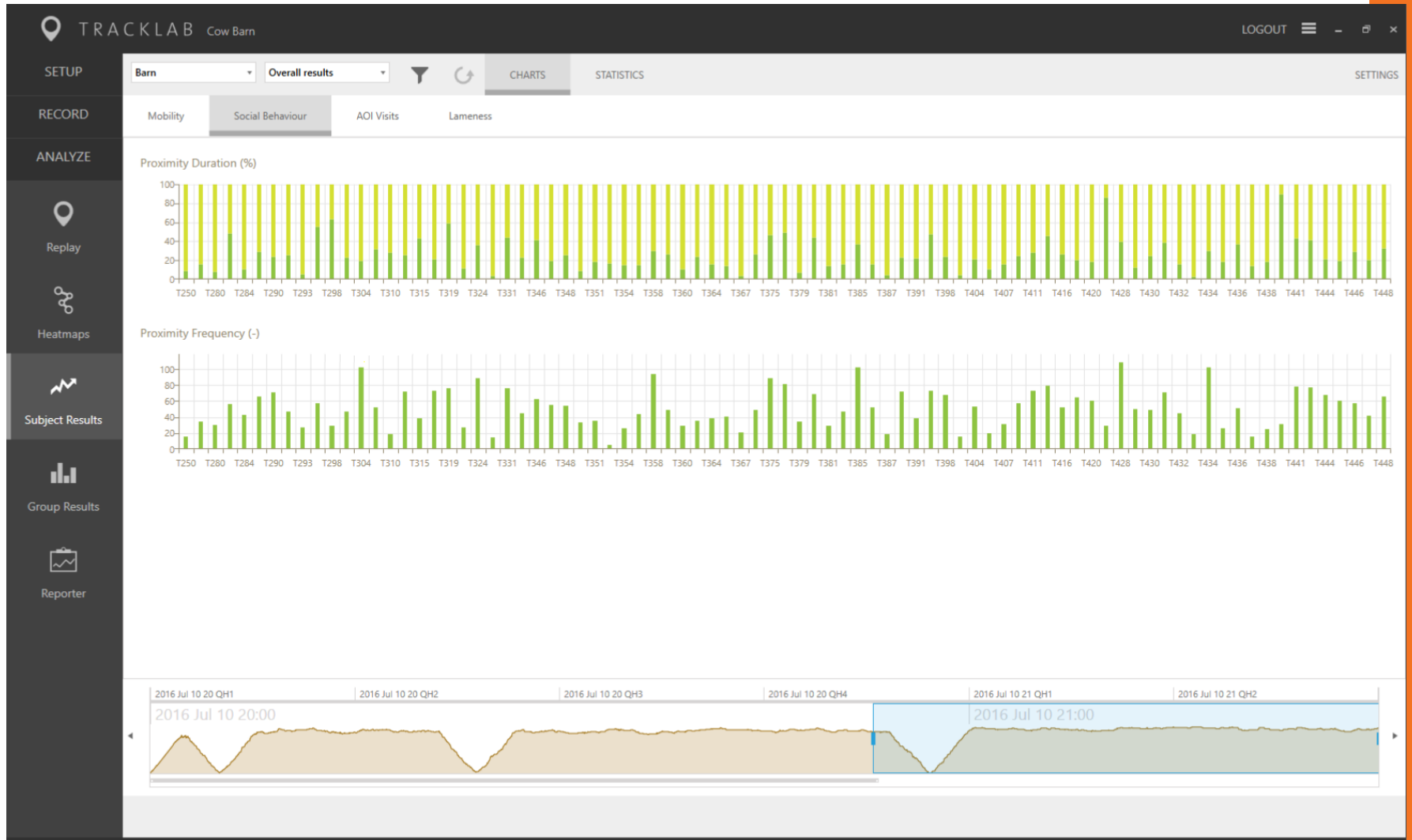
TrackLab: Timetable heatmap



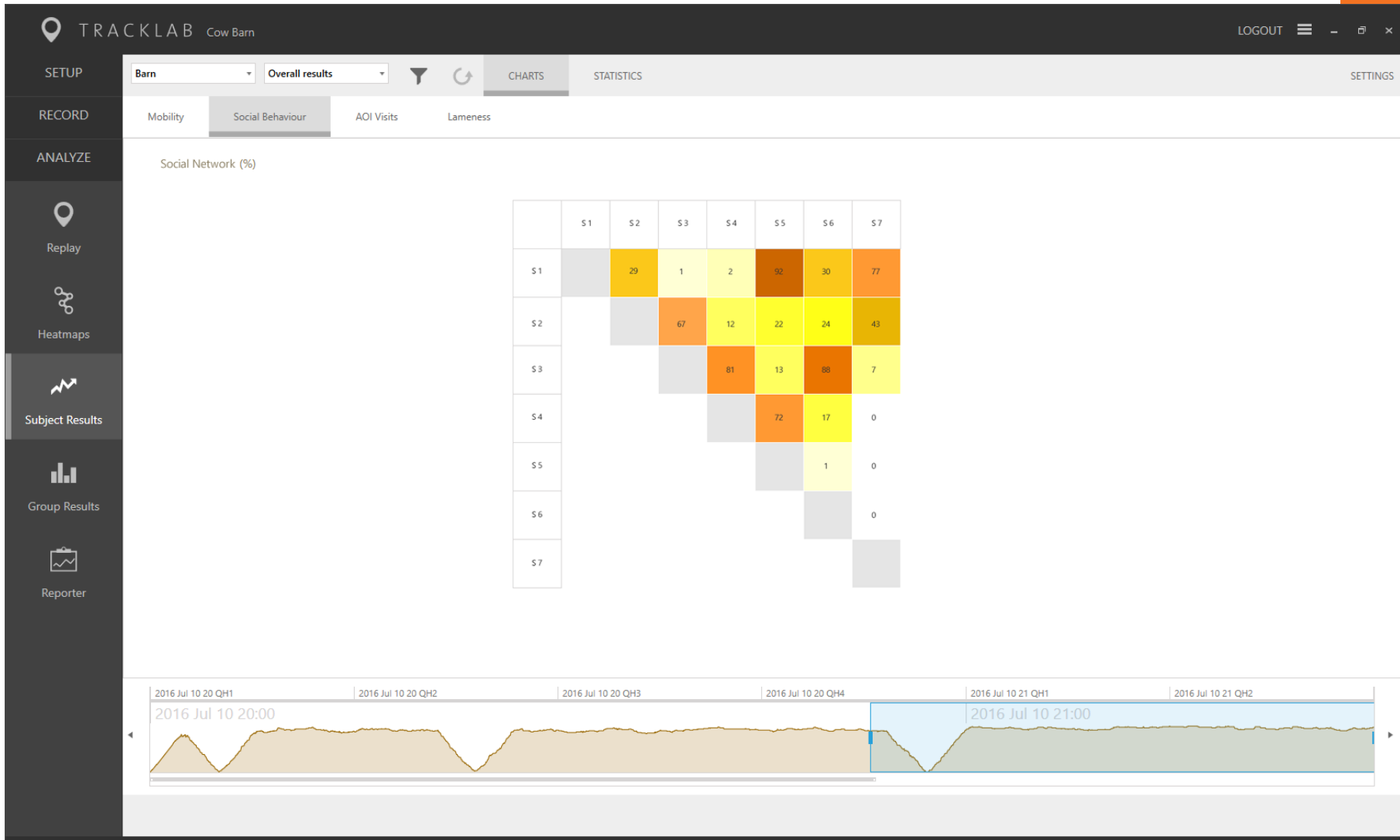
TrackLab: Area visit statistics



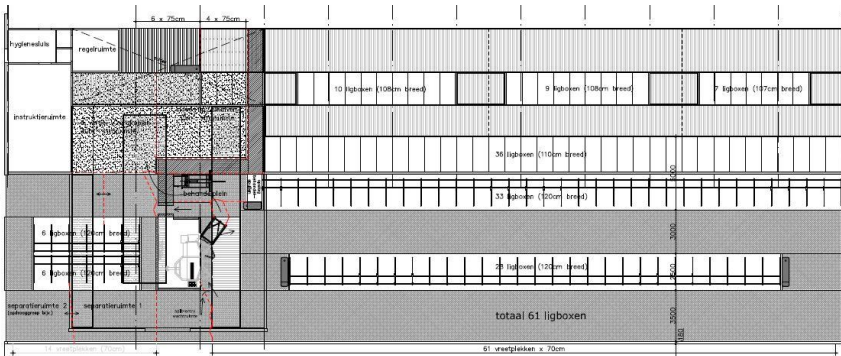
TrackLab: Social behavior – proximity statistics



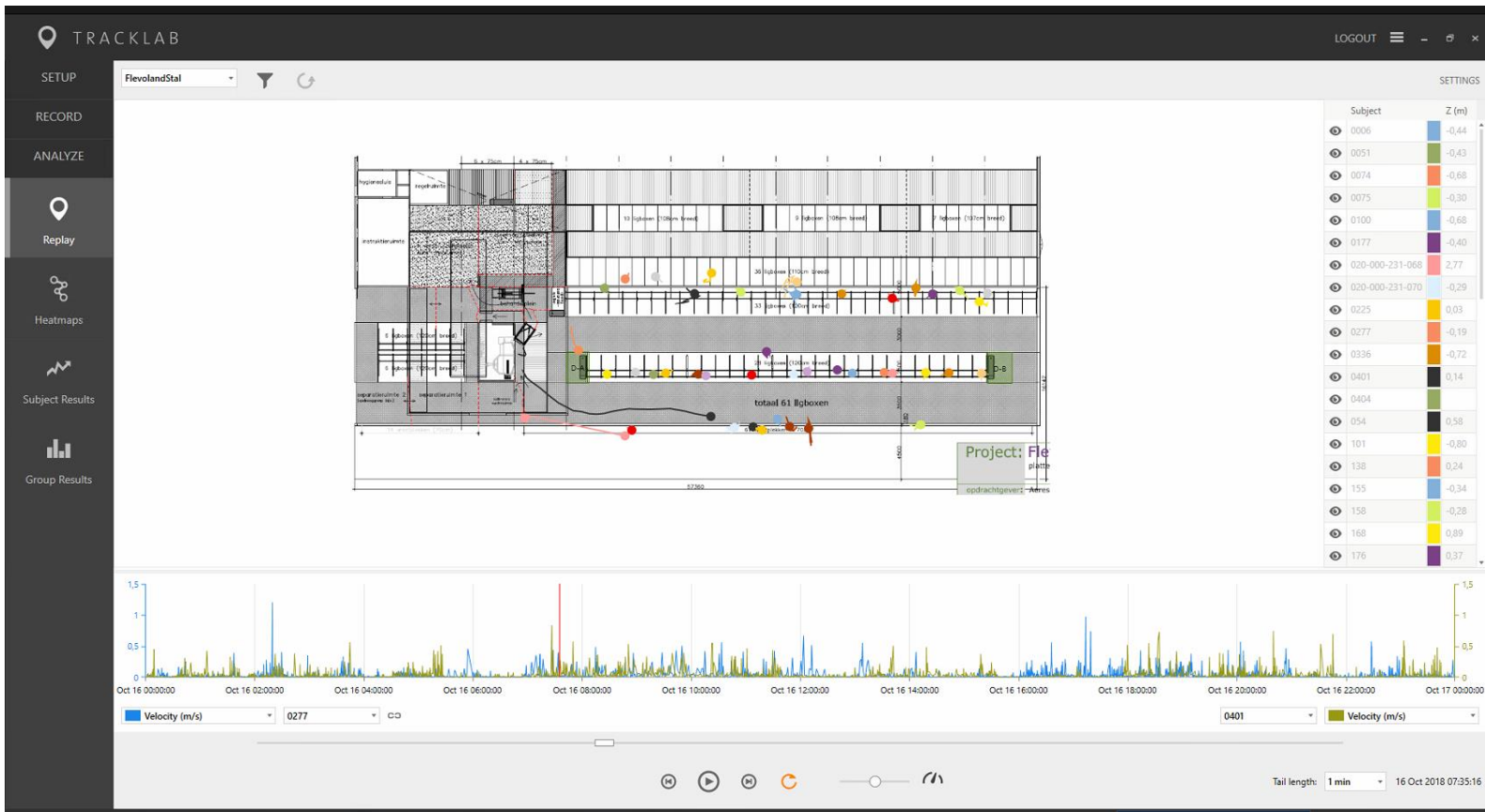
TrackLab: Social behavior – pair relations



Aeres University of Applied Sciences Dronten, Netherlands



Aeres University of Applied Sciences Dronten, Netherlands



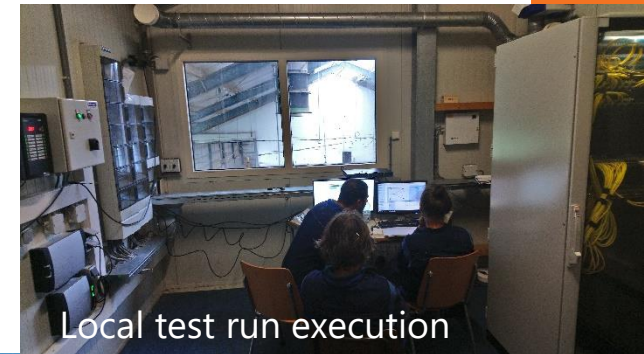
Dairy Campus (Wageningen University) Leeuwarden, Netherlands



Straw bed



Porous textile bed



Local test run execution



Sensor calibration



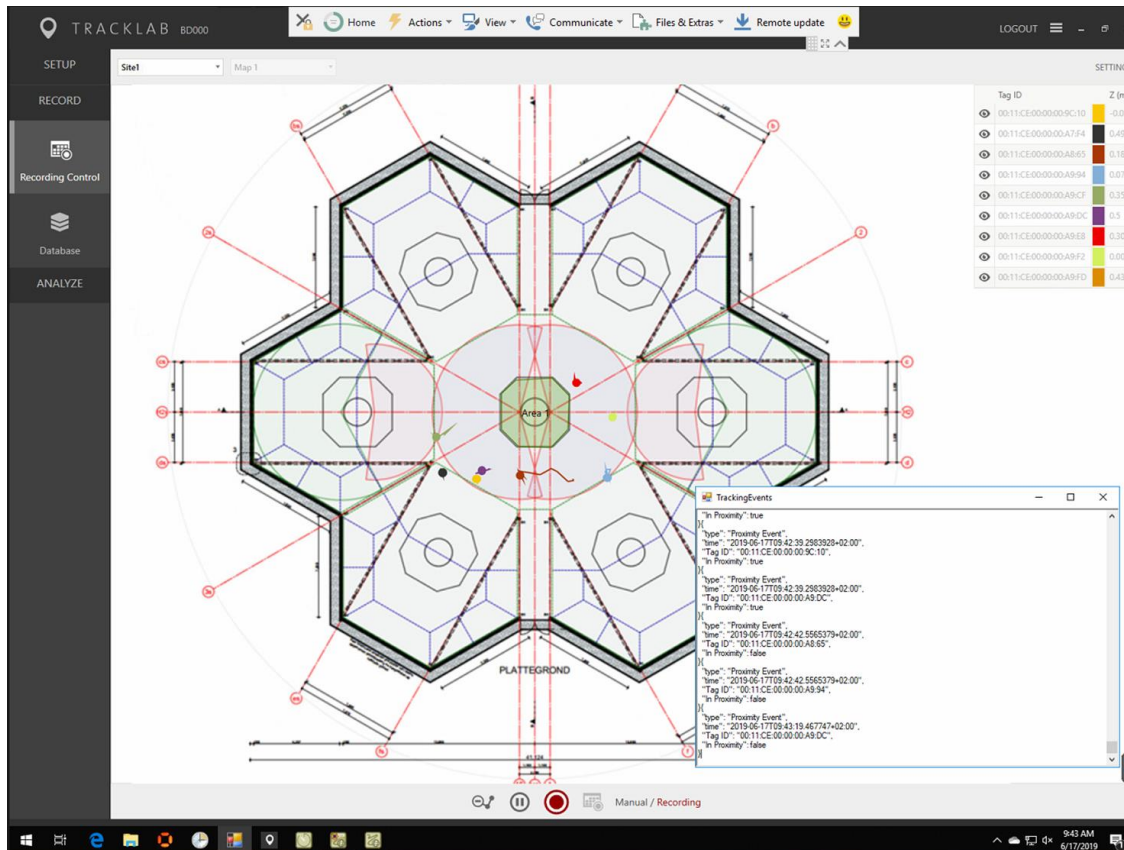
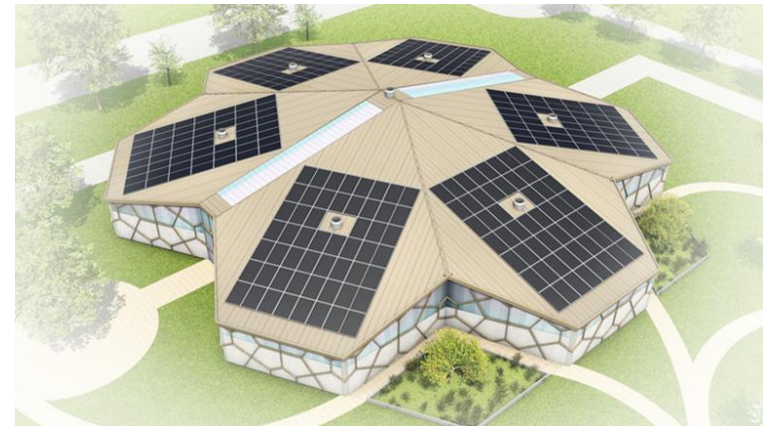
Remote monitoring (wired or wireless)

TRACKLAB SITE

Animal Sciences Group, Wageningen University Wageningen, Netherlands

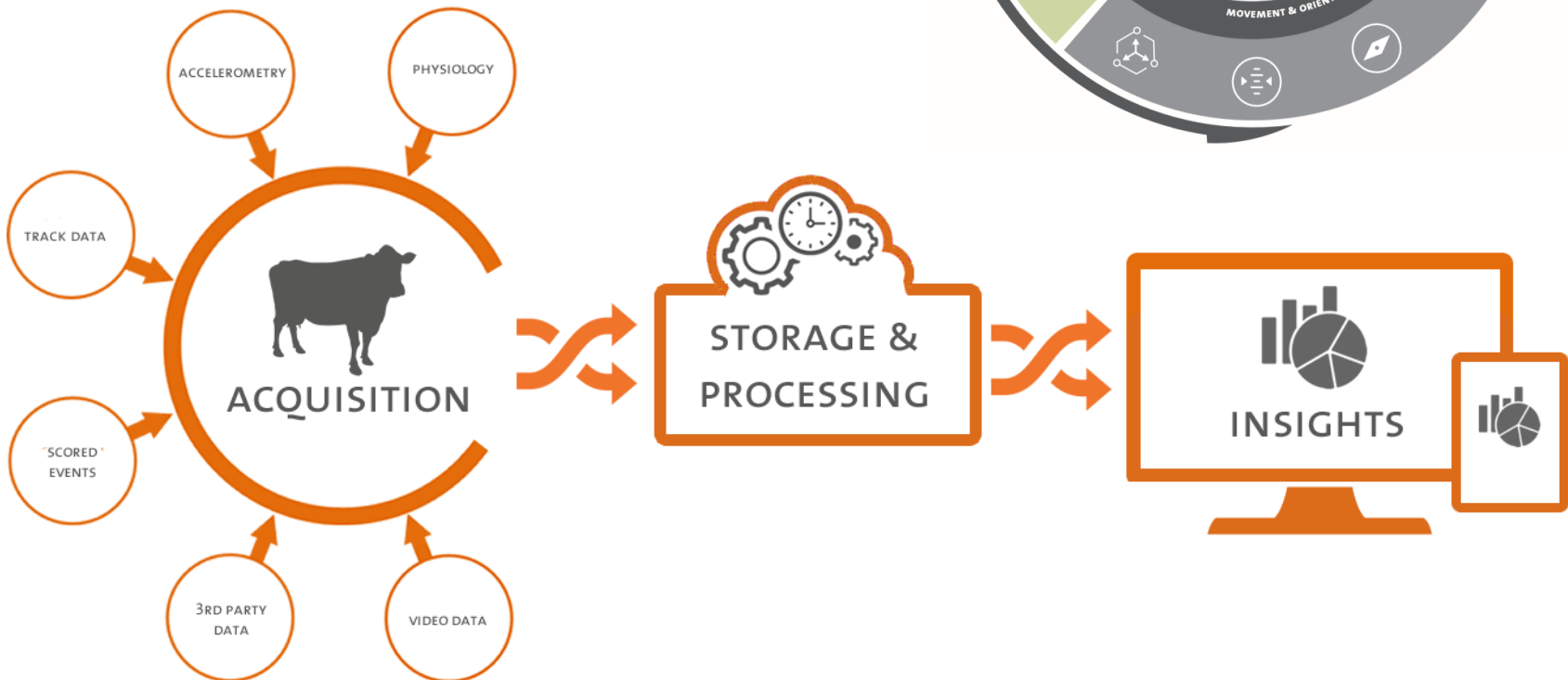


Family Pig Farm Venhorst, Netherlands



- First use in practical (pig) farming context
- Behavior analysis output (subject proximities, area visits) is used as input for individualized feeding and toilet systems
- Improve animal welfare, productivity and emissions reduction

TRACKLAB ROADMAP

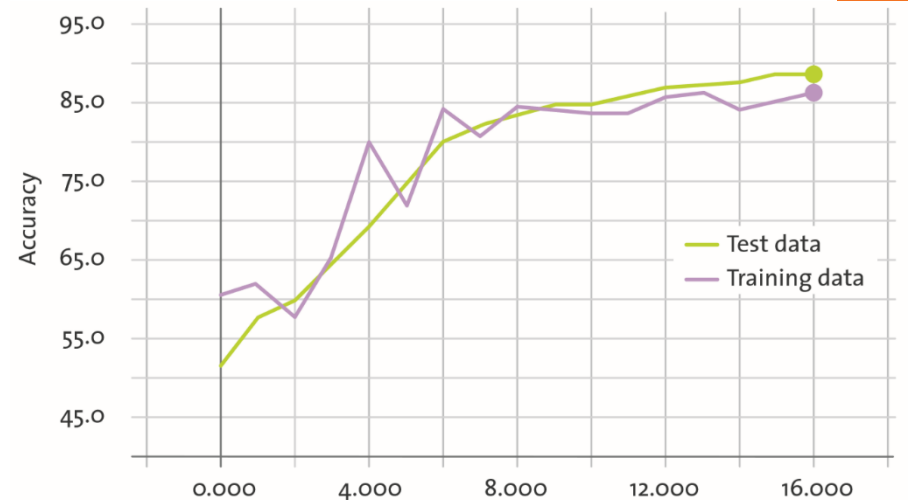
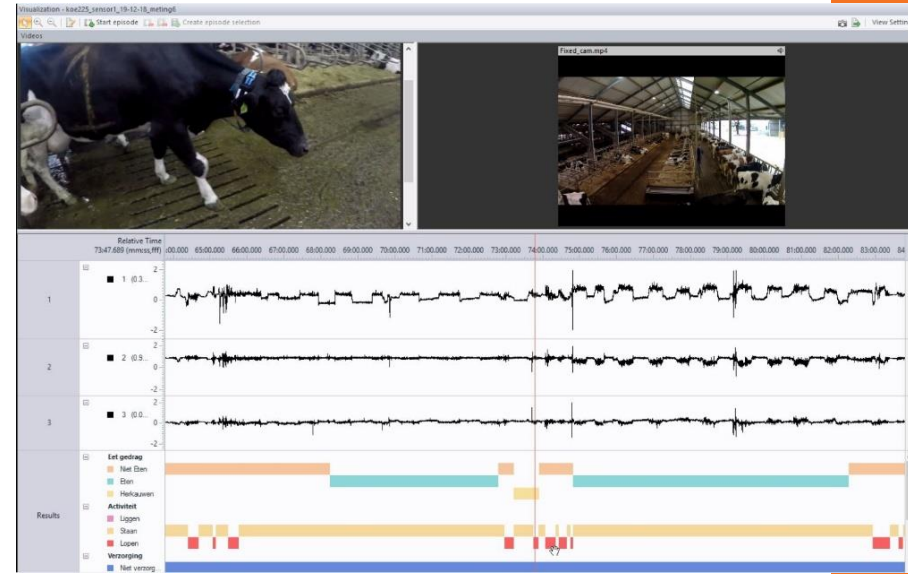


MULTISENSOR PATTERN RECOGNITION

- Sensor fusion and pattern recognition:
 - Detection of complex behaviors
 - Increased reliability of results
- Relevant livestock behaviors:
 - **Posture:** lying, standing, walking, falling, jumping
 - **Feeding:** eating, drinking, ruminating
 - **Social:** grooming
 - **Disease:** lameness
 - **Aggression:** tail biting, head butting, feather pecking
 - **Reproduction:** mounting, calving, estrus

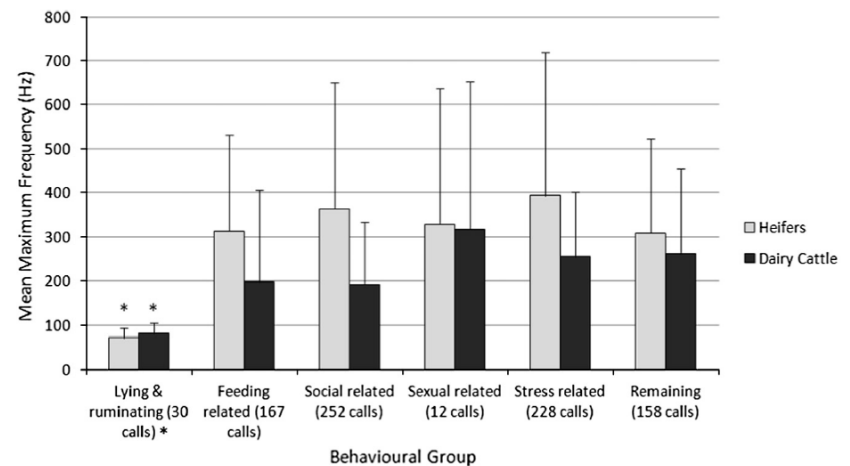
AUTOMATIC RECOGNITION OF COW BEHAVIOR

- Cows wearing neck sensor (3D accelerometer)
- Behaviors recorded on video and annotated in The Observer:
 - Walking, standing, lying
 - Eating, ruminating, not eating
- Deep learning model (Convolutional Neural Network + Gated Recurrent Unit) → classification accuracy (eating, ruminating, not eating): **~88%**



SOUND ANALYSIS

- Analyze animal vocalizations, e.g. in studies of animal welfare
- For cows, pigs, chicken

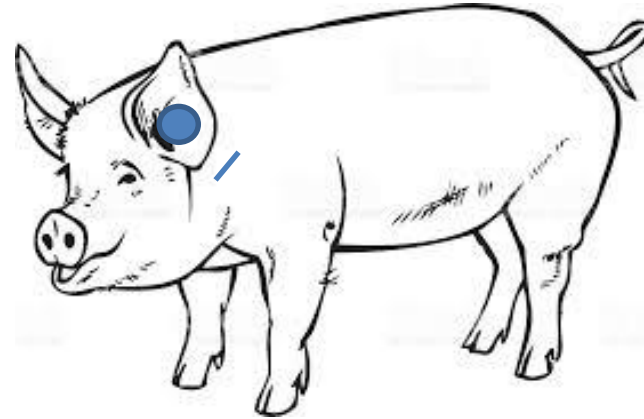
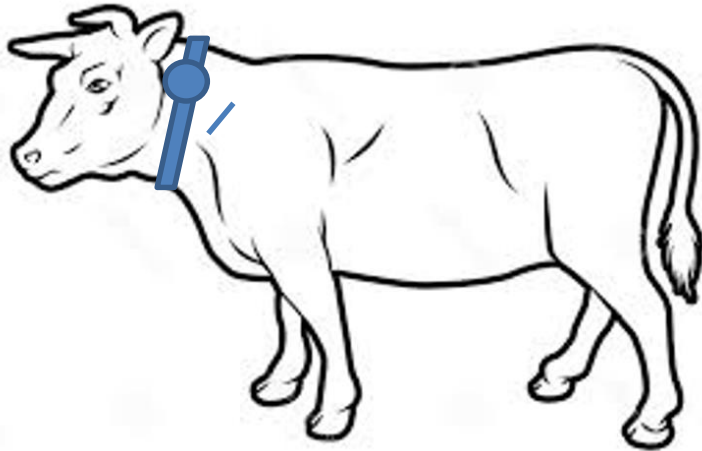


Sound analysis in dairy cattle vocalisation as a potential welfare monitor



G.H. Meen^{a,*}, M.A. Schellekens^{a,1}, M.H.M. Slegers^a, N.L.G. Leenders^a, E. van Erp-van der Kooij^a, L.P.J.J. Noldus^b

^a Department of Applied Biology, HAS University of Applied Sciences, 's-Hertogenbosch, The Netherlands
^b Noldus Information Technology B.V., Wageningen, The Netherlands



External tag

- RFID reader
- Radio transmitter
- 3D accelerometer
- Battery
- Microprocessor
- Size: ~ 20x20 mm

Injectable capsule

- Thermosensor
- Passive RFID transponder
- Size: ~ 20x2 mm

Advantages

- Very small capsule, can be injected with syringe, no anesthesia, no recovery
- Capsule without battery, lasts forever



CONCLUSIONS



- TrackLab 2 was successfully tested with **cow**, **chicken** and **pig** behavior
- Tracking hardware:
 - Compatible with farm conditions (e.g. humidity, low temperature)
 - Works well on larger animals (cattle, pigs, adult chicken, sheep)
 - Needs to be optimized (lighter, smaller) for young birds and piglets
- We hope that TrackLab 2 will contribute to:
 - **Livestock research**: behavioral phenotyping, testing diets, welfare and health monitoring
 - **Precision livestock farming**: monitoring individual animal health and welfare, enhancing housing and management systems

ACKNOWLEDGEMENTS

Research and development presented here was partly funded by the following grants:



Veterinary Biocontained facility Network for excellence in animal infectiology research and experimentation

A European BSL3 infrastructures project



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731014



GenTORE is a Horizon 2020 project running from 1 June 2017 to 31 May 2022. This research received funding from the European Union's H2020 Research and Innovation Program under agreement No. 727213.



THANK YOU FOR
YOUR ATTENTION

Lucas P.J.J. Noldus, Ph.D.

Noldus Information Technology BV

Wageningen

The Netherlands

Phone: +31-317-473300

Email: lucas.noldus@noldus.nl

Web: www.noldus.com