Precision Dairy Management: Intelligent automatisieren!

Jeffrey Bewley, Amanda Sterrett, Randi Black, Barbara Wadsworth, Di Liang, Karmella Dolecheck, Matthew Borchers, Lauren Mayo, Nicky Tsai, Maegan Weatherly, Melissa Cornett, Samantha Smith, Megan Hardy, and Jenna Klefot

Where I Come From


The Future
NEXT EXIT

Technological Marvels

- Tremendous technological progress in dairy farming (i.e. genetics, nutrition, reproduction, disease control, cow comfort)
- Modern dairy farms have been described as “technological marvels” (Philpot, 2003)
- The next “technological marvel” in the dairy industry may be in Precision Dairy Farming

1. Changing Dairy Landscape

- Fewer, larger dairy operations
- Narrow profit margins
- Increased feed and labor costs
- Cows are managed by fewer skilled workers

2. Consumer Focus

- Continuous quality assurance
- “Natural” or “organic” foods
- Greenhouse gas reductions
- Zoonotic disease transmission
- Reducing the use of medical treatments
- Increased emphasis on animal well-being

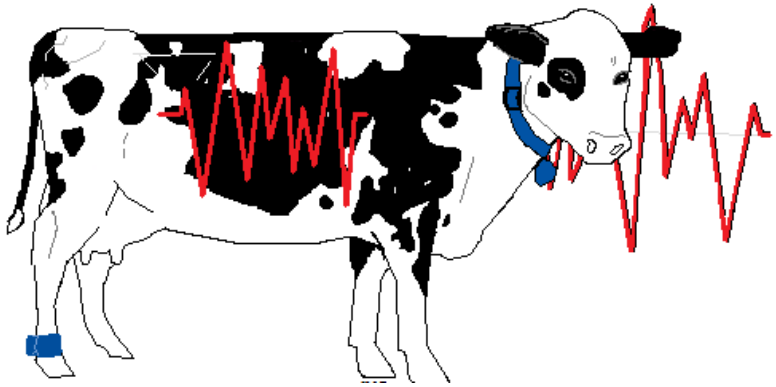
3. Information Era

- Unlimited on-farm data storage
- Faster computers allow for more sophisticated on-farm data mining
- Technologies adopted in larger industries have applications in smaller industries

4. Cow Challenges

1. Finding cows in heat
2. Finding and treating lame cows
3. Finding and treating cows with mastitis
4. Catching sick cows in early lactation
5. Understanding nutritional status of cows
    a. Feed intake
    b. Body condition (fat or thin)
    c. Rumen health (pH/rumination time)

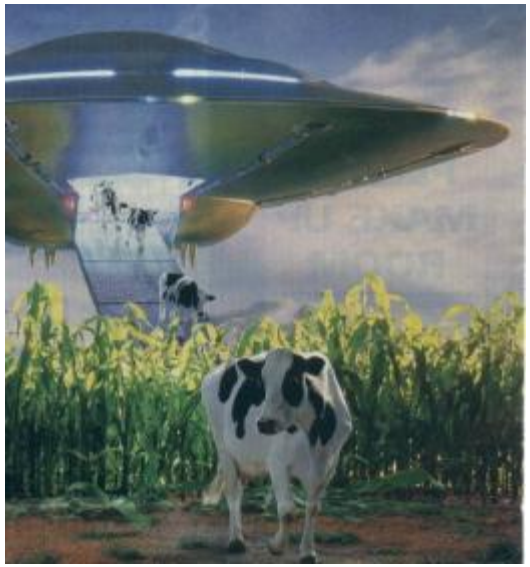
Precision Dairy Management

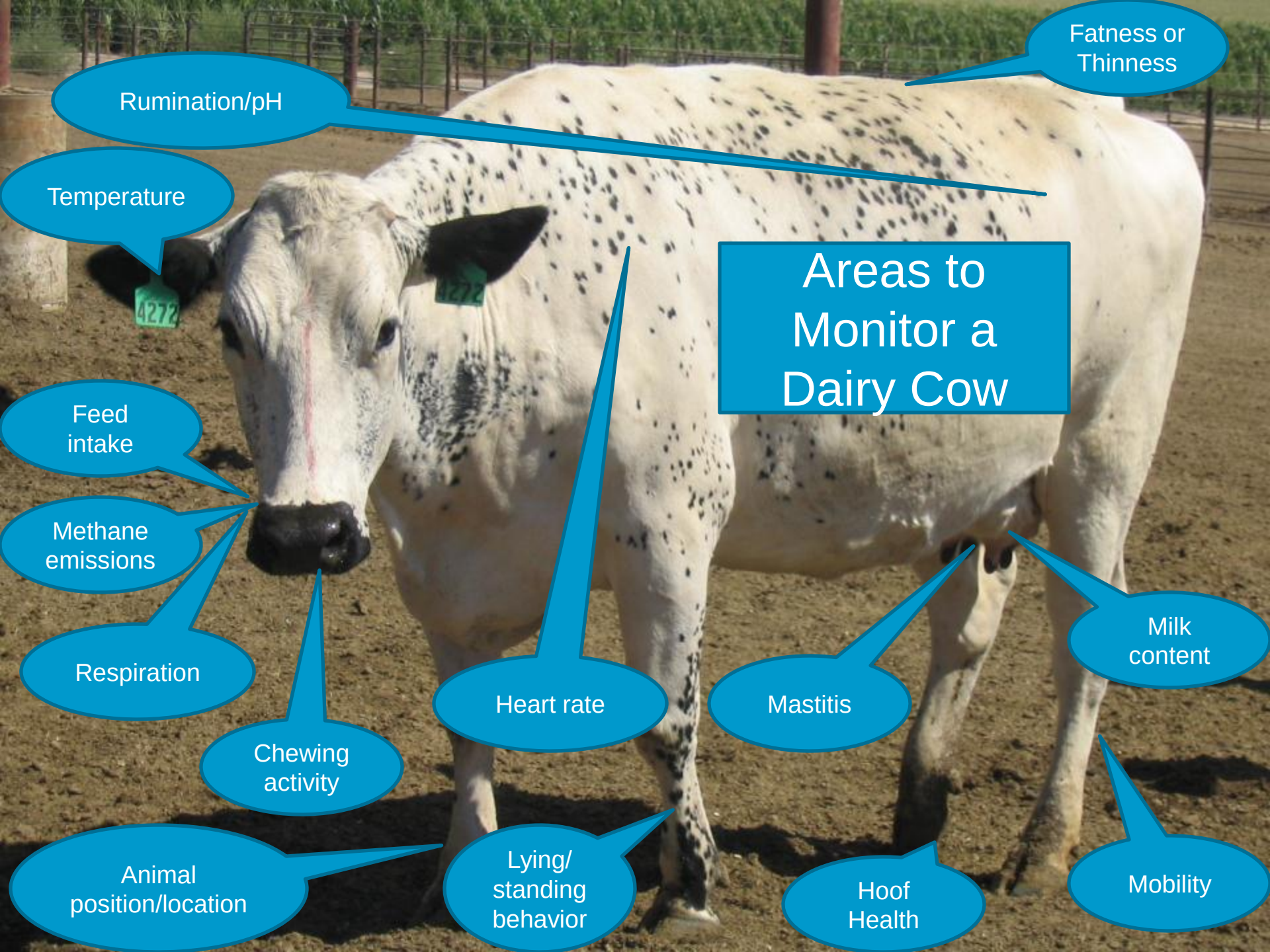


The use of automated, mechanized technologies toward refinement of dairy management processes, procedures, or information collection

Precision Dairy Monitoring

- Using technologies to measure physiological, behavioral, and production indicators
- Focus on preventive health and performance at the cow level
- Make more timely and informed decisions




Areas to Monitor a Dairy Cow
Fatness or Thinness
Rumination/pH
Temperature
Feed intake
Methane emissions
Respiration
Chewing activity
Heart rate
Mastitis
Milk content
Animal position/location
Lying/ standing behavior
Hoof Health
Mobility

Precision Dairy Farming Benefits

- Improved animal health and well-being
- Increased efficiency
- Reduced costs
- Improved product quality
- Minimized adverse environmental impacts
- More objective (less observer bias and influence)

What Technologies are Out There?

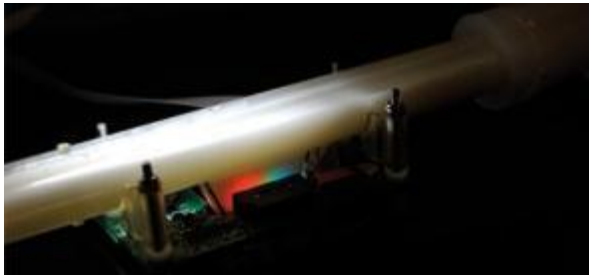
Electrical Conductivity

- Ion concentration of milk changes, increasing electrical conductivity
- Inexpensive and simple equipment
- Wide range of sensitivity and specificity reported
- Results improve with quarter level sensors
- Improved results with recent algorithms
- Most useful when combined with other metrics

Brandt et al., 2010; Hogeveen et al., 2011

Milk Color

- Color variation (red, blue, and green) sensors in some automatic milking systems
- Reddish color indicates blood (Ordolff, 2003)
- Clinical mastitis may change color patterns for three colors (red, green and blue)
- Specificity may be limited



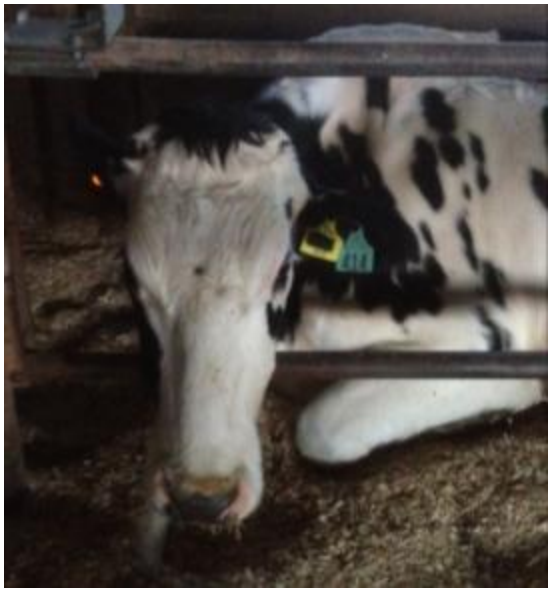
THE POWER WITHIN

Core body temperature monitoring has promise as a mastitis detection tool.

BY KIM SCHOONMAKER

Temperature

- Not all cases of mastitis result in a temperature response
- Best location to collect temperature?
- Noise from other physiological impacts



Thermography

- May be limited because not all cases of mastitis result in a temperature response
- Difficulties in collecting images

Before Infection

After Infection

Agricam

Hovinen et al., 2008; Schutz, 2009

Automated CMT or WMT

- CellSense (New Zealand)
- Correlation with Fossomatic SCC 0.76 (Kamphuis et al., 2008)
- Using fuzzy logic, success rates (22 to 32%) and false alerts (1.2 to 2.1 per 1000 milkings), when combined with EC were reasonable (Kamphuis et al., 2008)

Mastiline

- Uses ATP luminescence as an indicator of the number of somatic cells
- Consists of 2 components
- In-line sampling and detection system, designed for easy connection to the milk hose below the milking claw
- Cassette containing the reagents for measuring cell counts

Spectroscopy

- Visible, near-infrared, mid-infrared, or radio frequency
- Indirect identification through changes in milk composition
- AfiLab uses near infrared
  - Fat, protein, lactose, SCC, and MUN
- May be more useful for detecting high SCC cows than quantifying actual SCC

Milk measurements

- Progesterone
  - Heat detection
  - Pregnancy detection
- LDH enzyme
  - Early mastitis detection
- BHBA
  - Indicator of subclinical ketosis
- Urea
  - Protein status

Estrus Detection

- Efforts in the US have increased dramatically in the last 2 years
- Producer experiences are positive
- Changing the way we breed cows
- Only catches cows in heat
- Real economic impact

SCR HR Tag/AI24

GEA Rescounter II

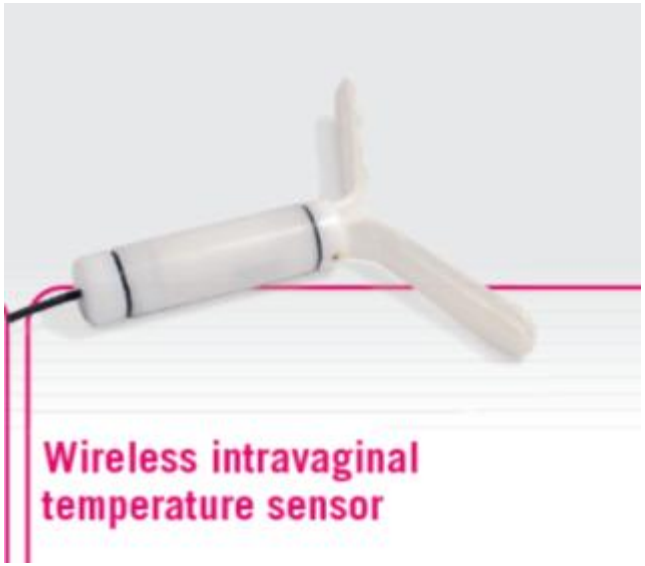
DairyMaster MooMonitor/ SelectDetect

AFI Pedometer +

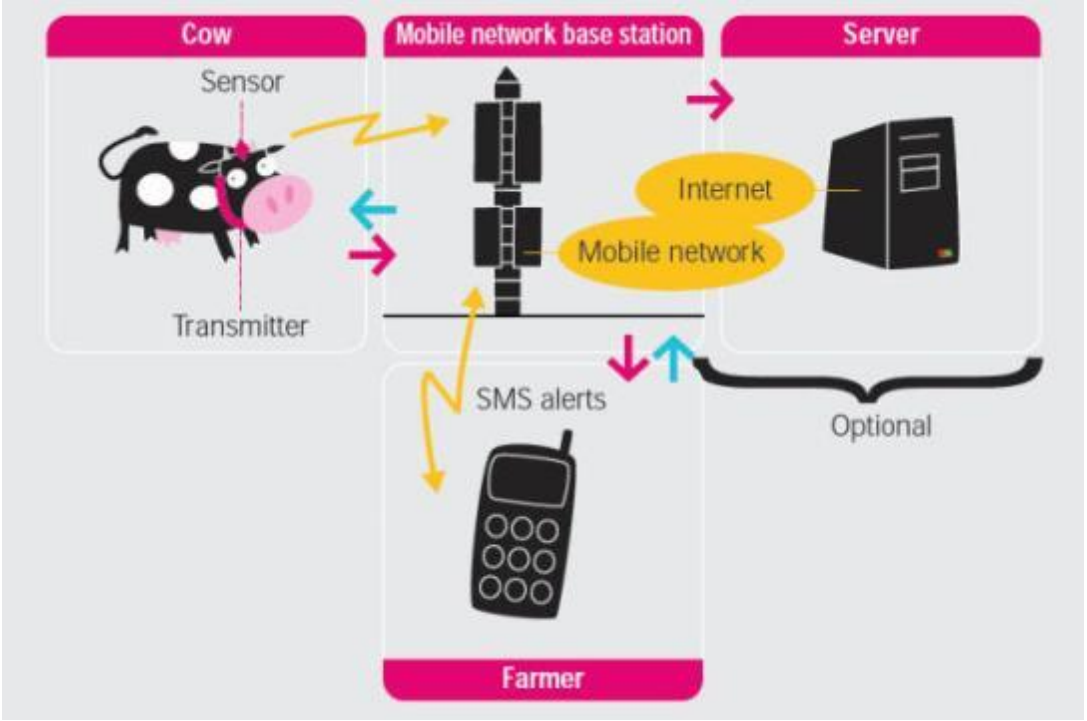
BouMatic HeatSeeker II

Track a Cow

ANEMON
animal estrus monitoring



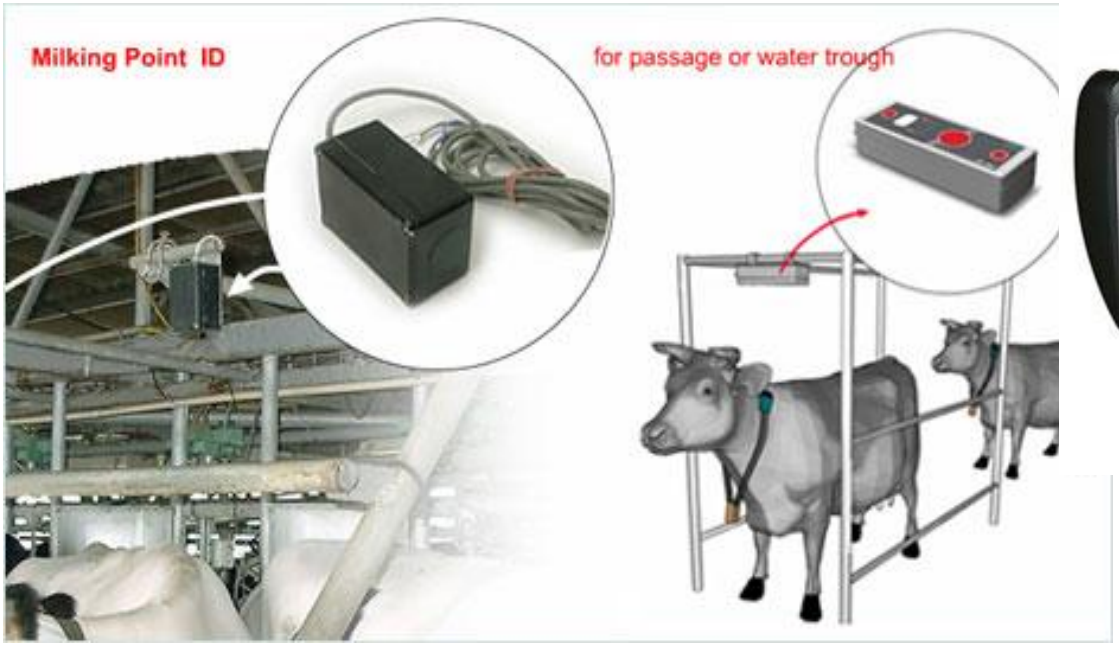
Wireless intravaginal temperature sensor



SCR HR Tag

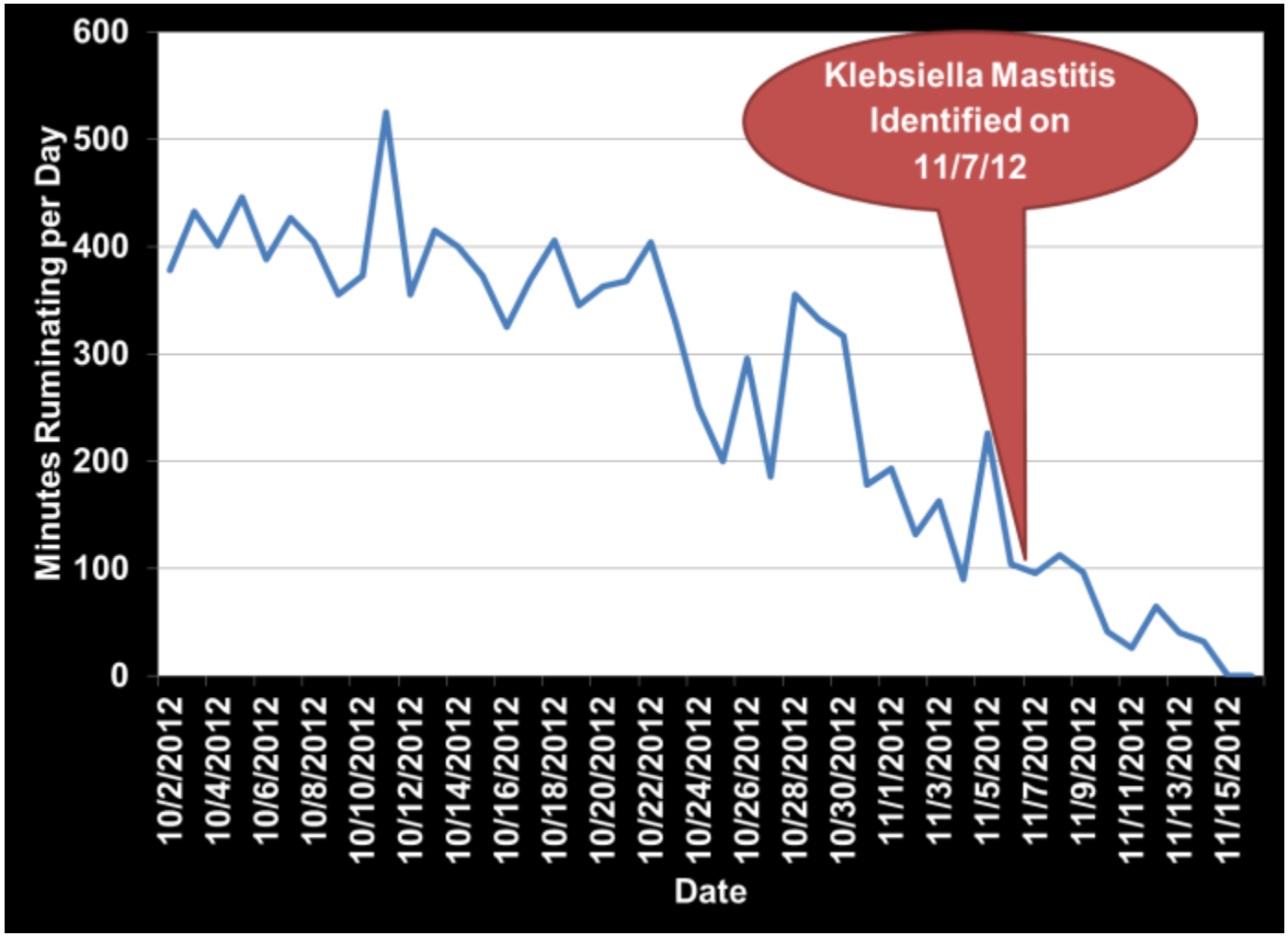
- **Measures rumination time**
- **Time between cud boluses**
- **Monitor metabolic status**

SCR
PRECISE DAIRY FARMING



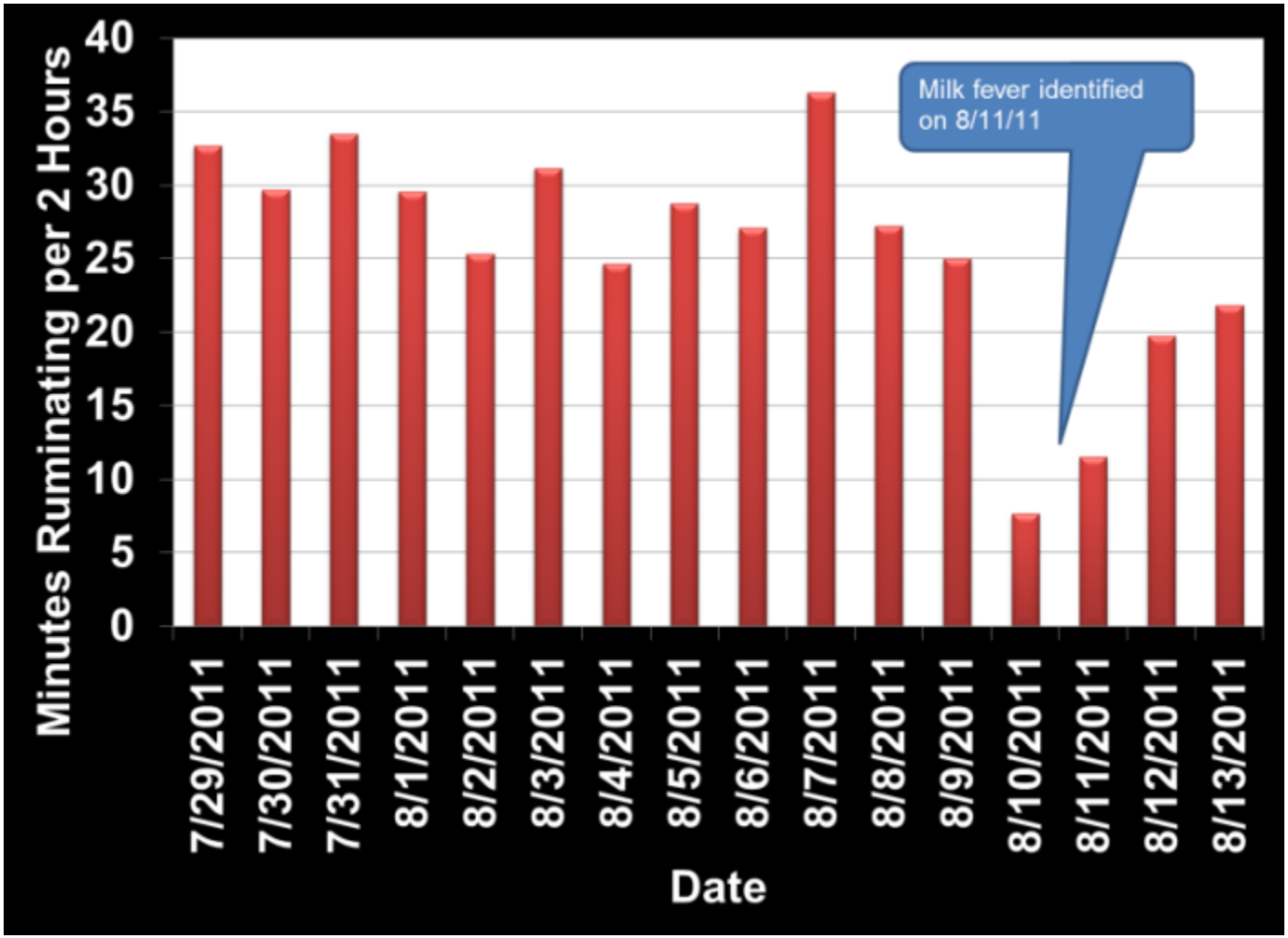
Cow with tag- 'HR Tag'

SCR Rumination Time



Amanda Sterrett et al.

SCR HR Tag for Milk Fever Detection



Amanda Sterrett et al. , Unpublished Data

Lying Behavior Monitors

- On-farm evaluation of lying time:
  - Identification of cows requiring attention (lameness, illness, estrus)
  - Assessment of facility functionality/cow comfort
  - Potential metric to assess animal well-being

Rumen pH

- Illness
- Feeding/drinking behavior
- Acidosis

Vel'Phone Calving Detection

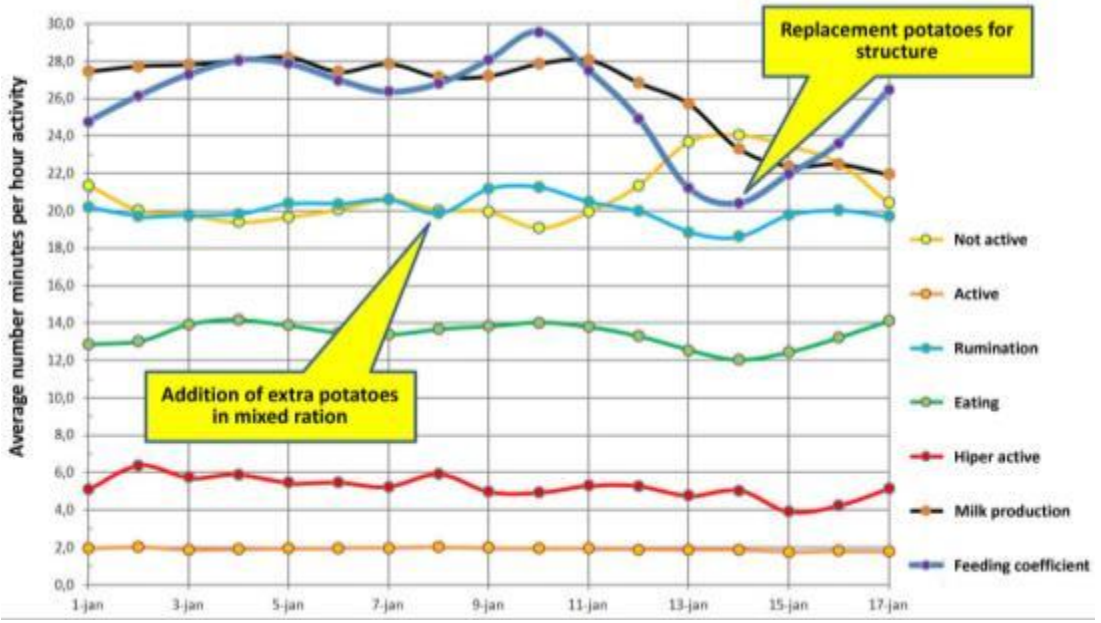
STEP 1	STEP 2	STEP 3	STEP 4	STEP 5
Thermometer is placed in the animal	Thermometer registers temperature rise	Typical variation in the animal's temperature	Thermometer expelled by water bag	Calving begins
	SMS message Thermometer activated*	SMS message Calving expected within 48 hrs	SMS message Thermometer expelled	

*Once the thermometer is activated the animal's temperature is sent by SMS once or twice a day at the selected times.

Medria*
ELEVAGE
Monitoring solutions

CowManager Sensoor

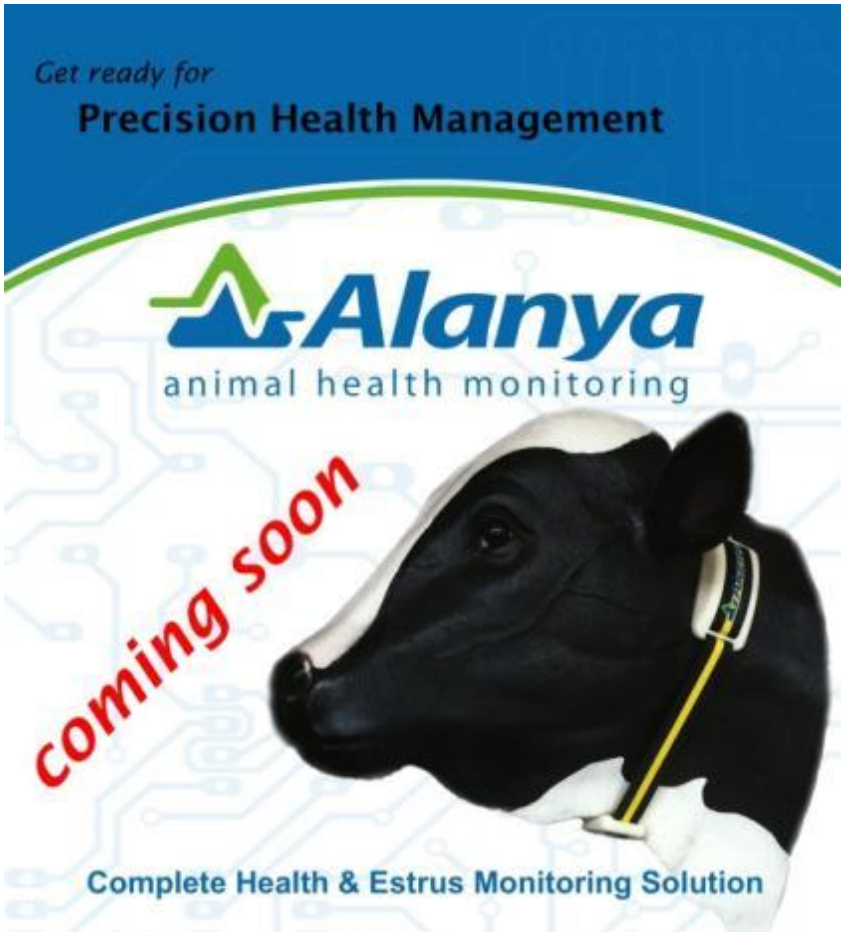
- **Temperature**
- **Activity**
- **Rumination**
- **Feeding Time**



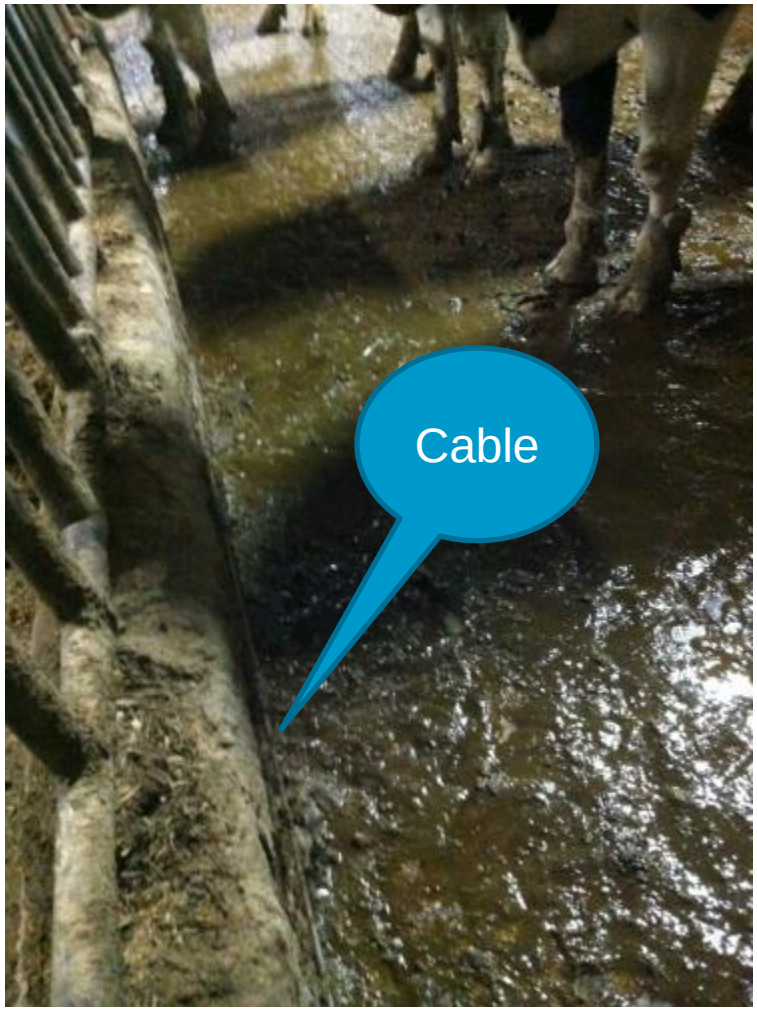
CowManager

Alanya Animal Health

- **Behavioral changes**
- **Temperature**
- **Lying/Standing Time**
- **Grazing Time**
- **Lameness**
- **Estrus Detection (multiple metrics)**
- **Locomotion Scoring**

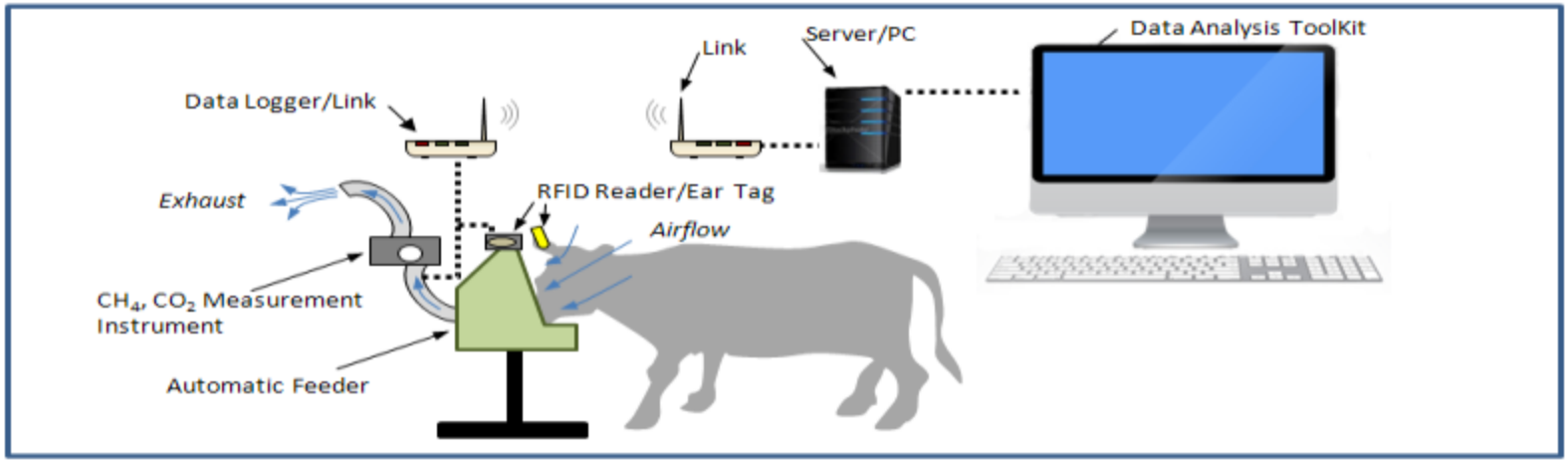


ENGS Track a Cow: Feeding Time



C-LOCK INC.

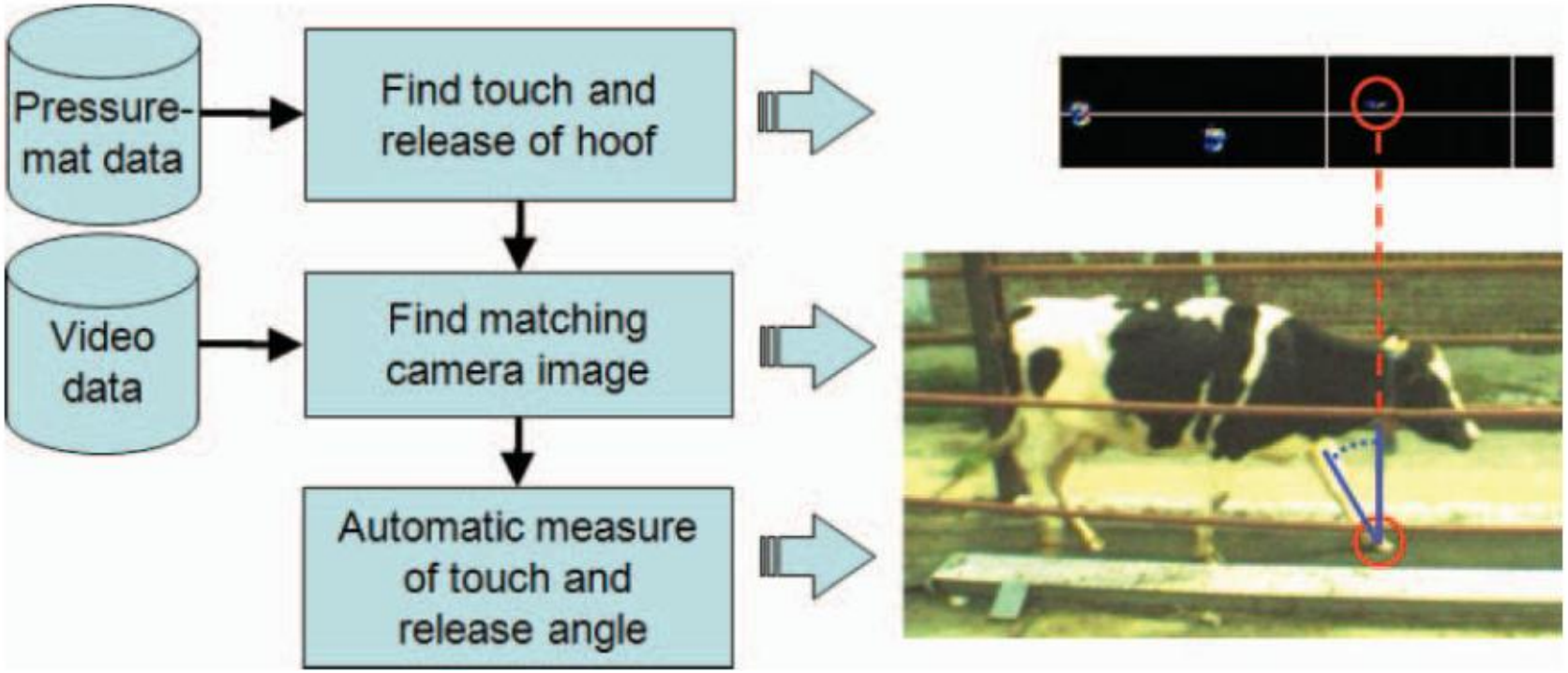
- Greenfeed measures methane (CH_4)
- Select for cows that are more environmentally friendly
- Monitor impacts of farm changes (rations) on greenhouse gas emissions



StepMetrix

- Lameness detection
- BouMatic

Belgian Lameness System



J. Dairy Sci. 95:1738–1748
http://dx.doi.org/10.3168/jds.2011-4547

Automatic measurement of touch and release angles of the fetlock joint for lameness detection in dairy cattle using vision techniques

A. Pluk,* C. Bahr,* A. Poursaberi,* W. Maertens,† A. van Nuffel,† and D. Berckmans*[1]
*Division of Measure, Model and Manage Bioresponses (M3-BIORES), Katholieke Universiteit Leuven, Kasteelpark Arenberg 30, B-3001 Leuven, Belgium
†Institute for Agricultural and Fisheries Research, Technology and Food Science Unit–Agricultural Engineering, B-9820 Merelbeke, Belgium

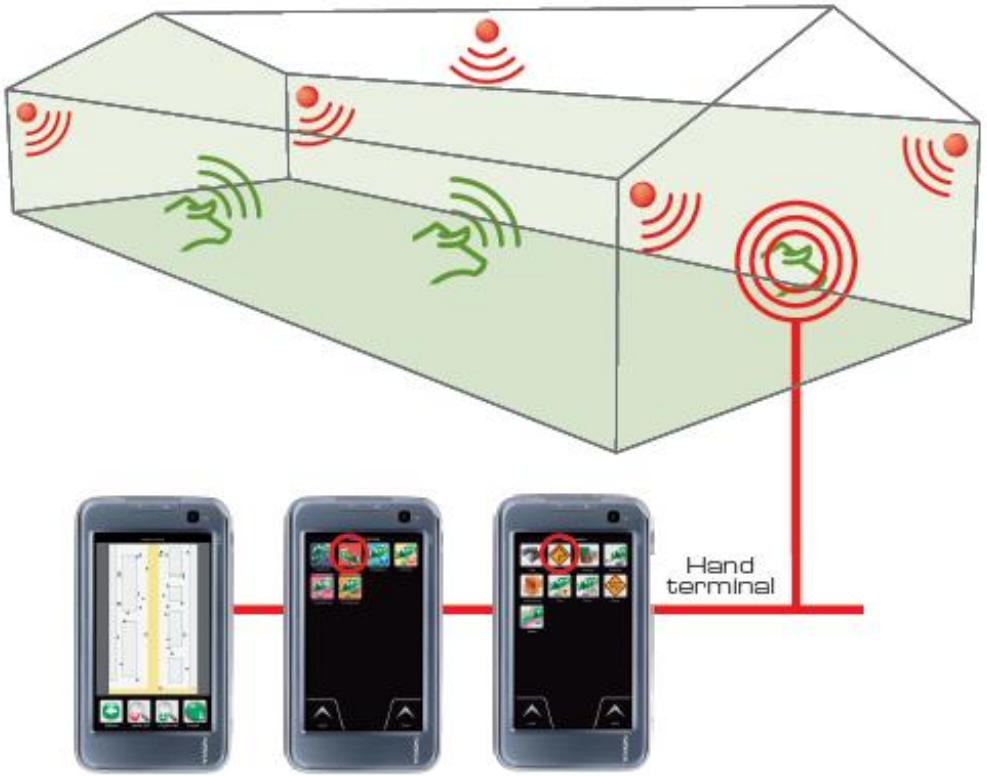
Real Time Location Systems

- Using Real Time Location System (RTLS) to track location of cows (similar to GPS)
- Better understand distribution of animals within barns
- Information used to design better barns and modify existing barns
- Behavior monitoring-implications for estrus detection, time at feedbunk, social interactions

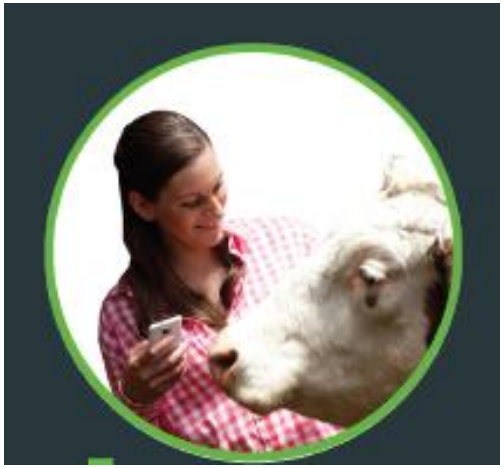
Randi Black et al.

GEA CowView

- Feeding time
- Waiting time
- Resting time
- Mounting
- Distance Covered



SmartBow



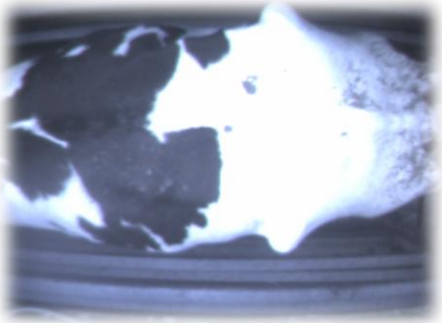
Summer 2013 UK Coldstream Dairy Monitoring Capabilities

UK UNIVERSITY OF KENTUCKY College of Agriculture
PRECISION DAIRY & COW ENVIRONMENT CONSORTIUM

Thank You to All our Consortium Sponsors!

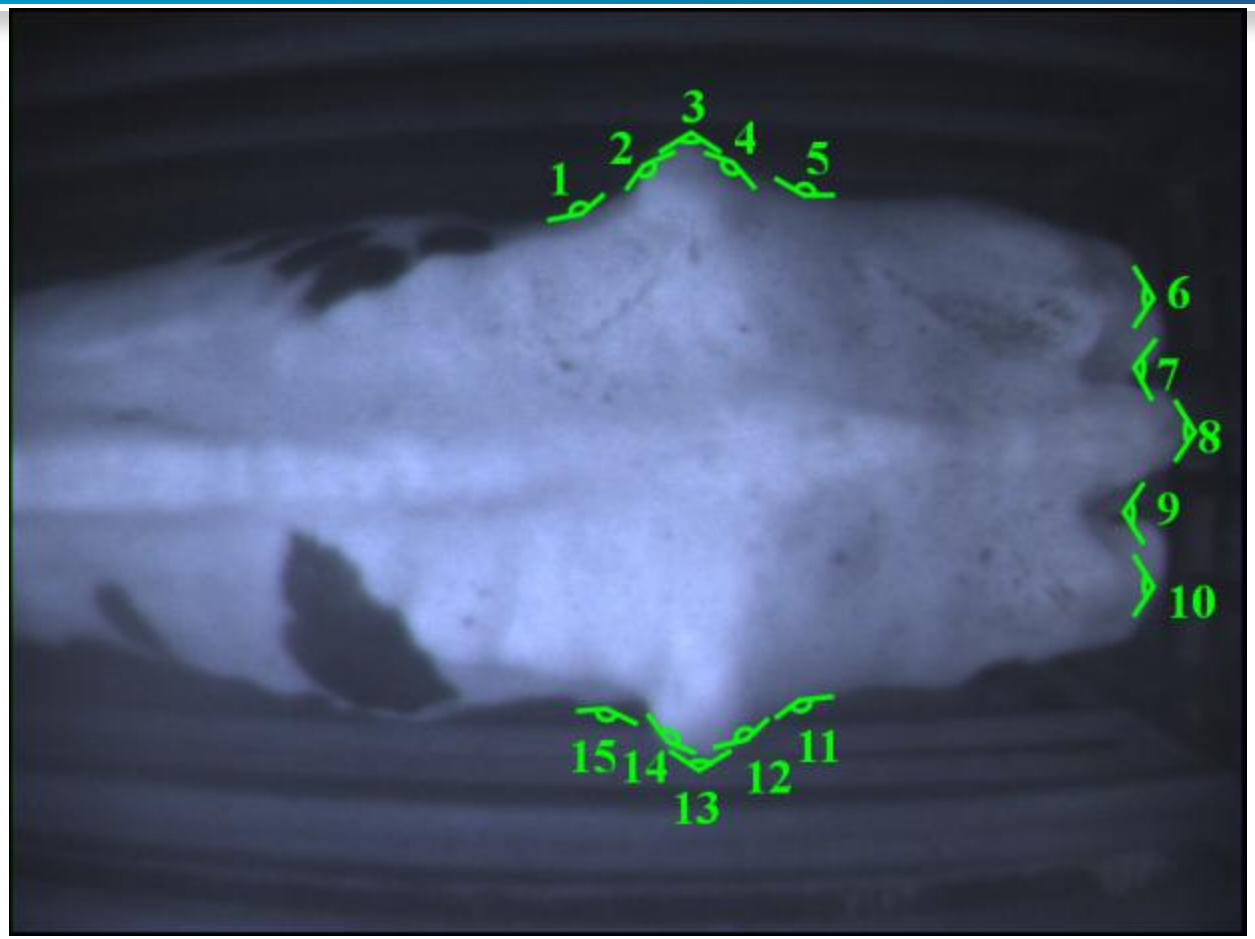
Technology	Parameter(s) Measured
SmartBow	Position, Movement
VelPhone	Calving Time, Vaginal Temperature
Alanya	Temperature, Lying Time, Activity, Locomotion, Behavior
AfiLab	Fat, Protein, Lactose
Pedometer Plus	Lying Time, Steps
HR Tag	Rumination Time, Neck Activity
Track-a-Cow	Lying Time, Time at Feedbunk
Mastiline	Somatic Cell Count
CowManager Sensoor	Rumination Time, Feeding Time, Ear Skin Temperature, Activity
IceQube	Lying Time, Steps, Locomotion
Anemon	Vaginal Temperature, Estrus
TempTrack	Reticulorumen Temperature
FeverTag	Tympanic Temperature
AccuBreed	Mounting Activity
CowScout	Leg Activity

Automated Body Condition Scoring



- Reduced labor requirements
- Less stressful on animal
- More objective, consistent measure
- Increased observation frequency
- Early identification of sick animals
- Tracking BCS trends of individual animals and management cohorts

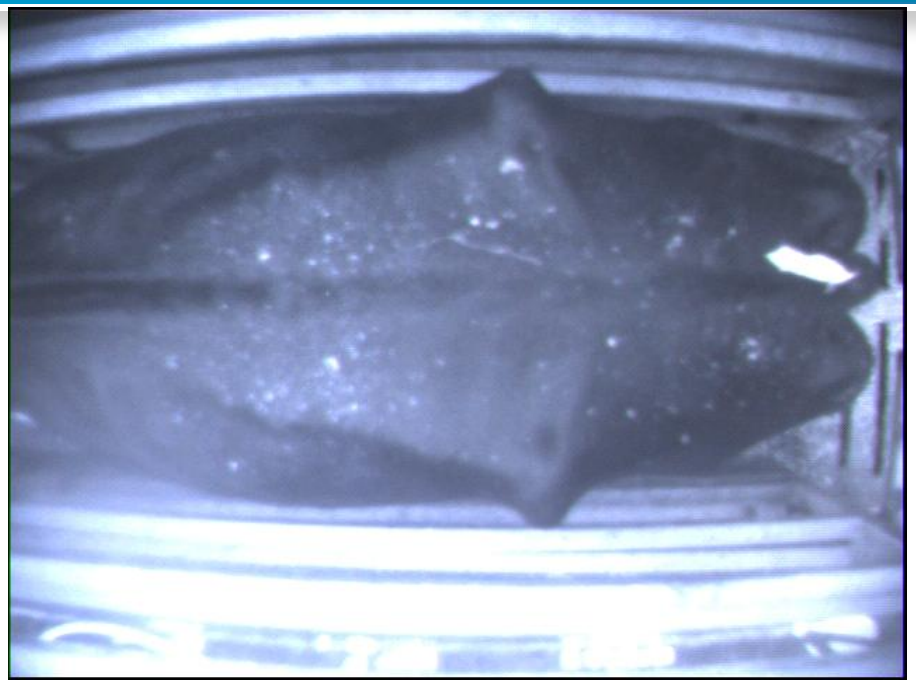
Body Condition Scoring

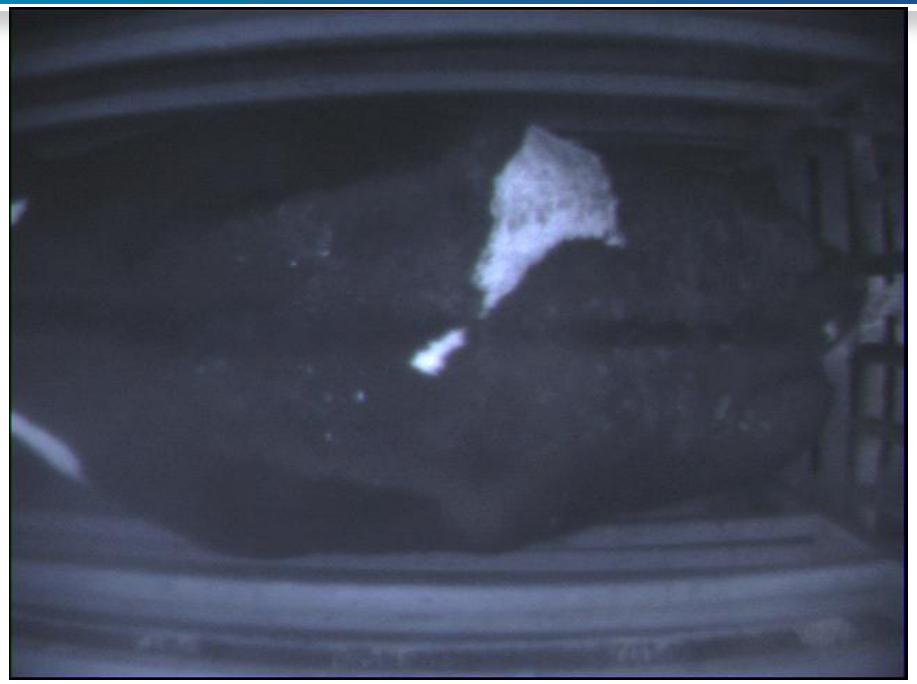


- **100% of predicted BCS were within 0.50 points of actual BCS.**
  - **93% were within 0.25 points of actual BCS.**

Bewley et al., 2008

Body Condition Scoring





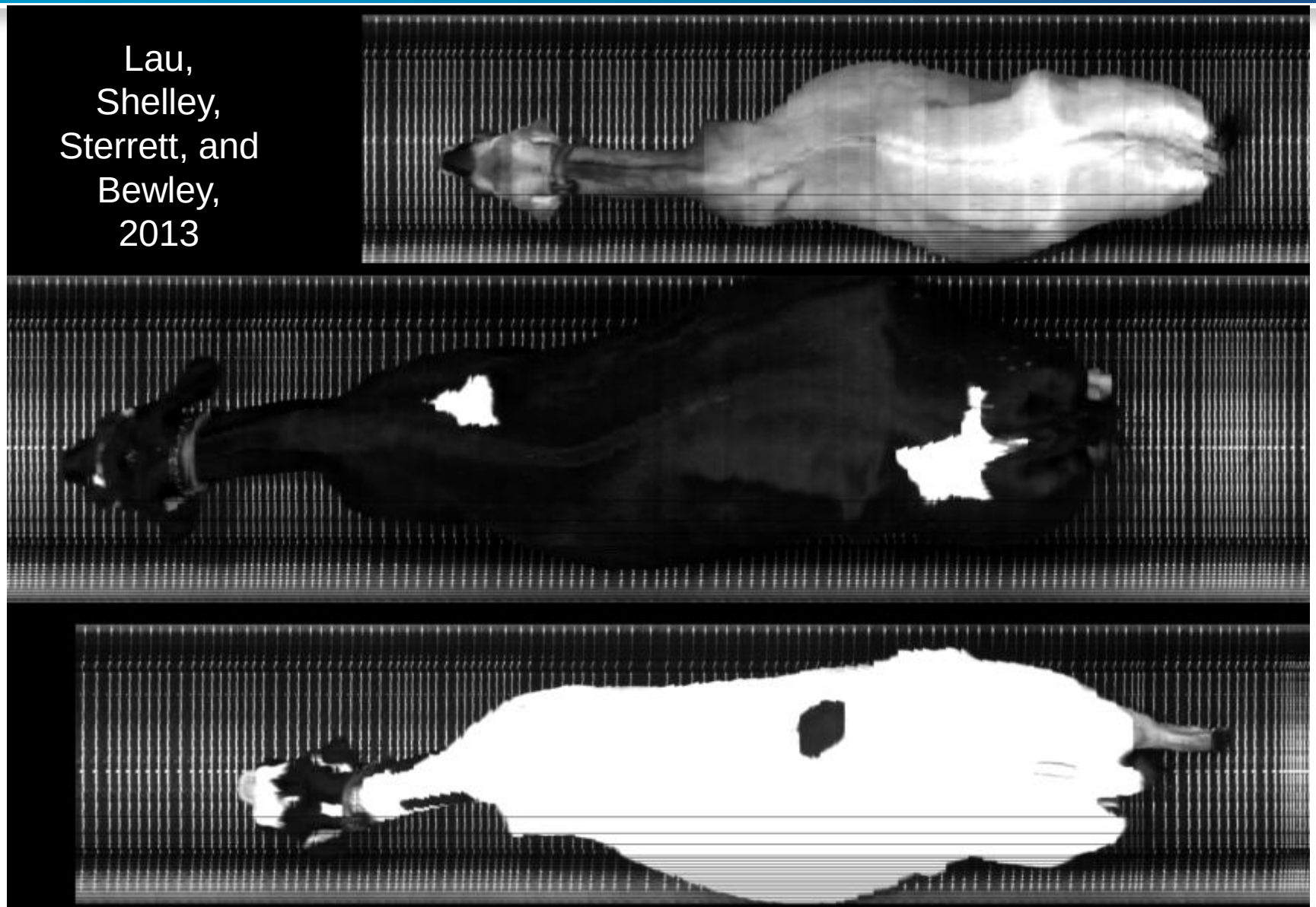
BCS	2.50
Predicted BCS	2.63
Posterior Hook Angle	150.0
Hook Angle	116.6

BCS	3.50
Predicted BCS	3.32
Posterior Hook Angle	172.1
Hook Angle	153.5

Bewley et al., 2008

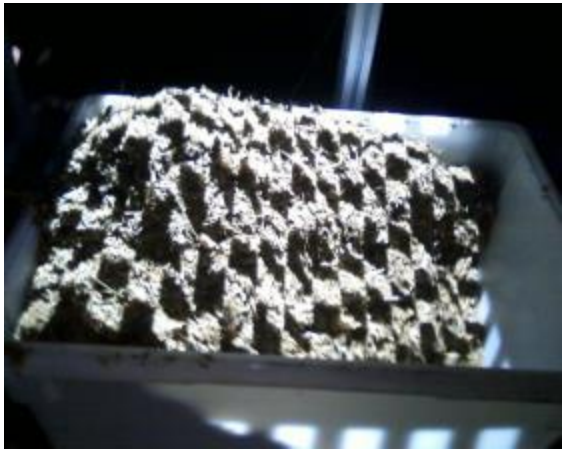
Now, Automation

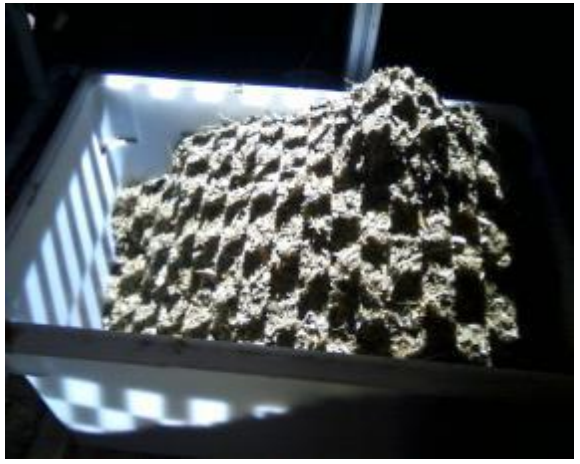
Lau, Shelley, Sterrett, and Bewley, 2013



Feed Intake: 3D Imaging

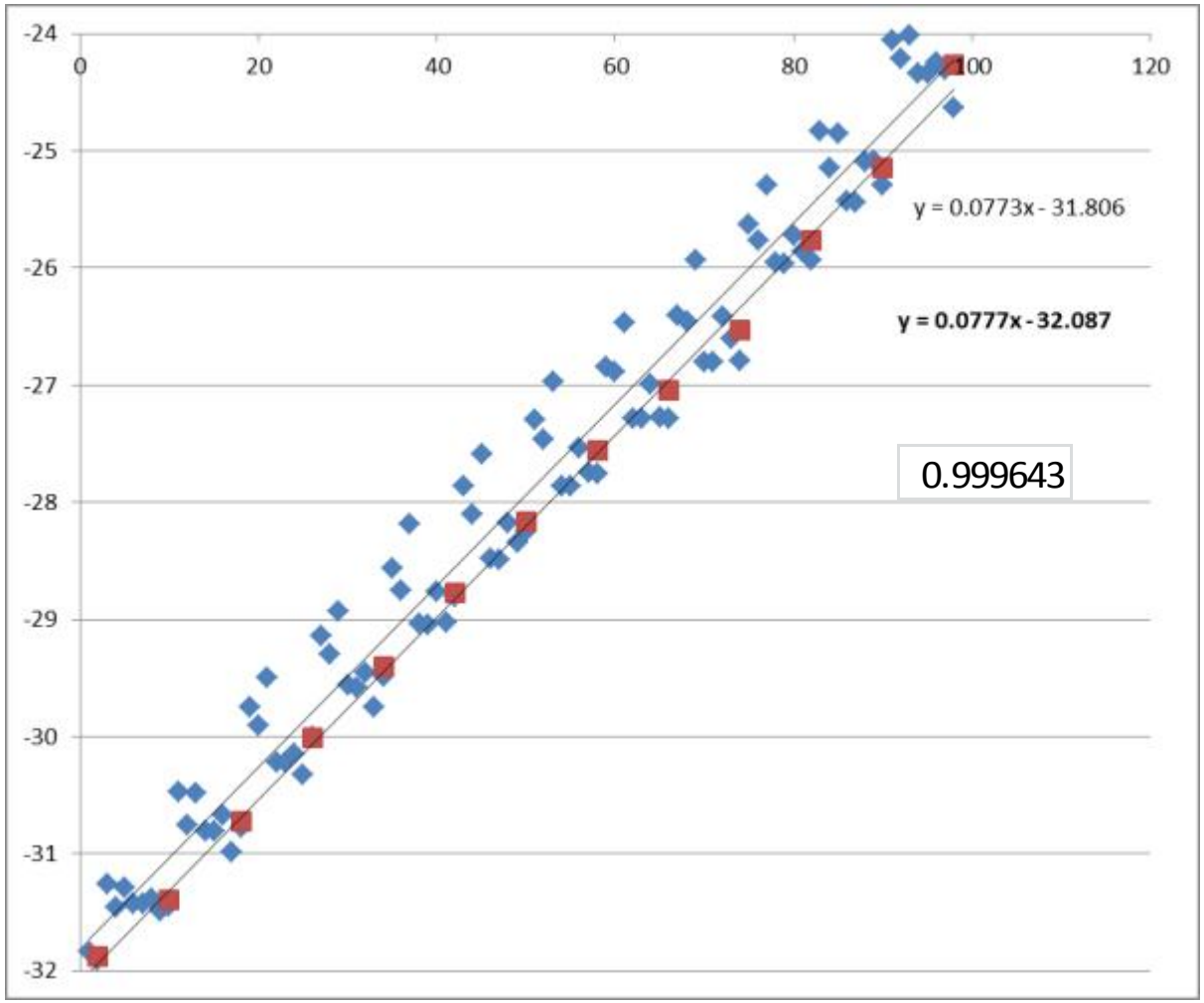




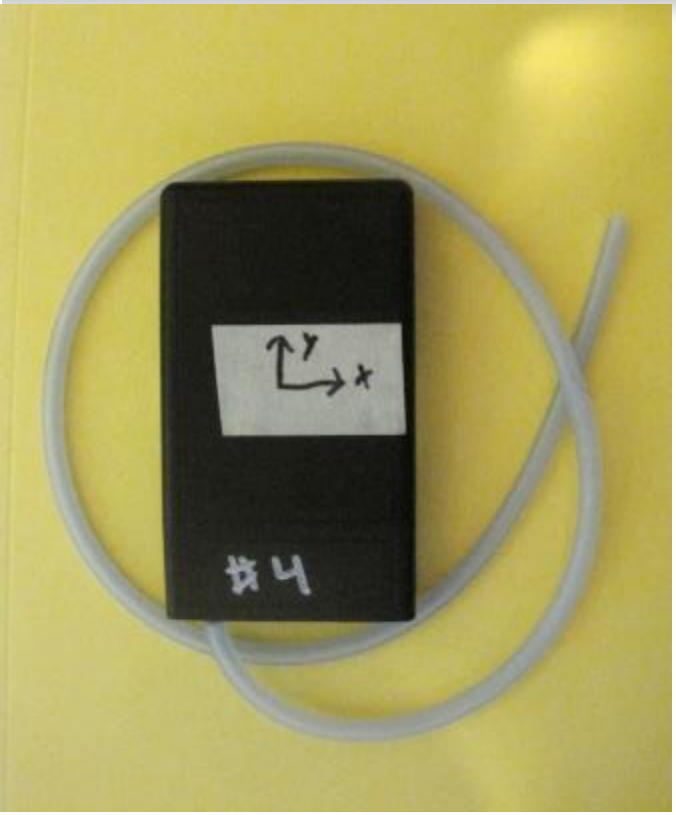
Lau, Shelley, Sterrett, and Bewley, 2013

Early Test Results



Lau, Shelley, Sterrett, and Bewley, 2013

Cow Sleep Monitoring



- Sleep Quality = Improved Immunity?
- New Way to Measure Cow Comfort?

Donohue, Llhamon, O'Hara, Klefot, and Bewley, 2013

What Are the Limitations of Precision Dairy Farming?

PDF Reality Check

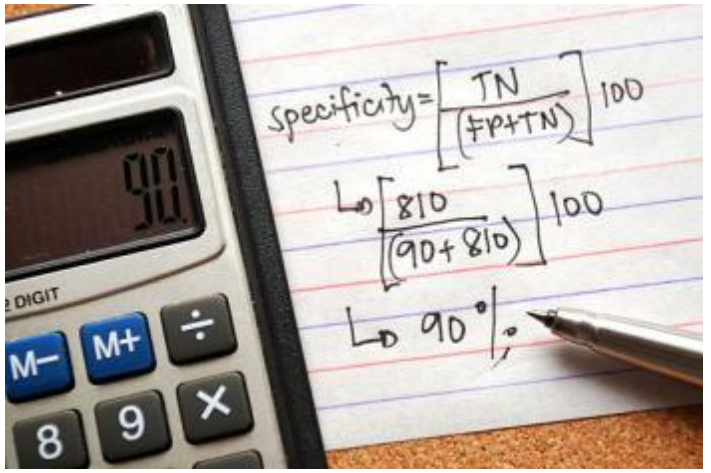
- Maybe not be #1 priority for commercial dairy producers (yet)
- Many technologies are in infancy stage
- Not all technologies are good investments
- Economics must be examined
- People factors must be considered

Ideal Technology

- Explains an underlying biological process
- Can be translated to a meaningful action
- Cost-effective
- Flexible, robust, reliable
- Information readily available to farmer
- Commercial demonstrations
- Continuous improvement and feedback loops

Data Handling

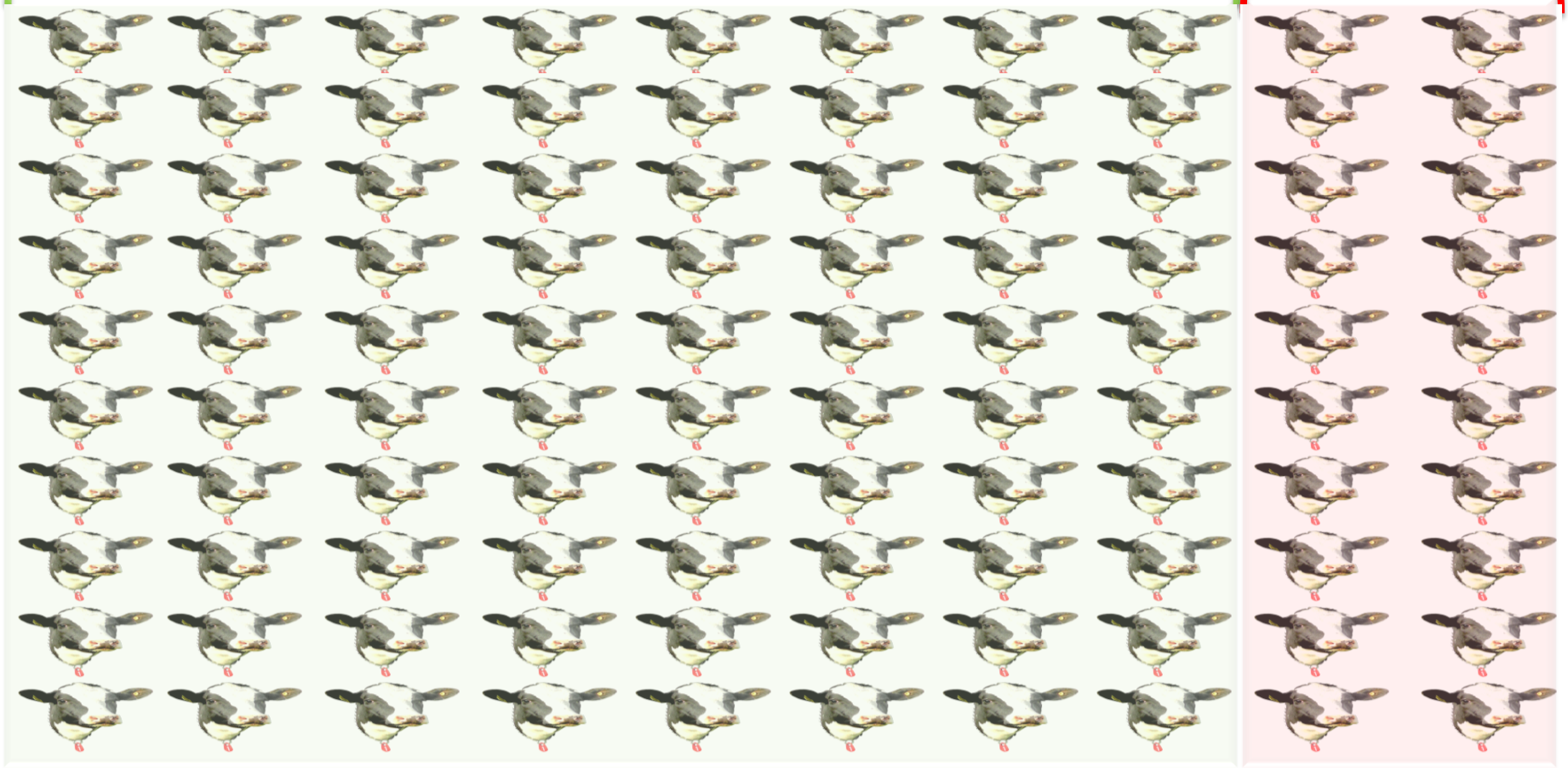
- Industry needs to establish guidelines for farmers to follow
- What questions should they be asking?
- What to do with information provided?



How Many Cows With Condition Do We Find?

80 Estrus Events Identified by Technology

20 Estrus Events Missed by Technology

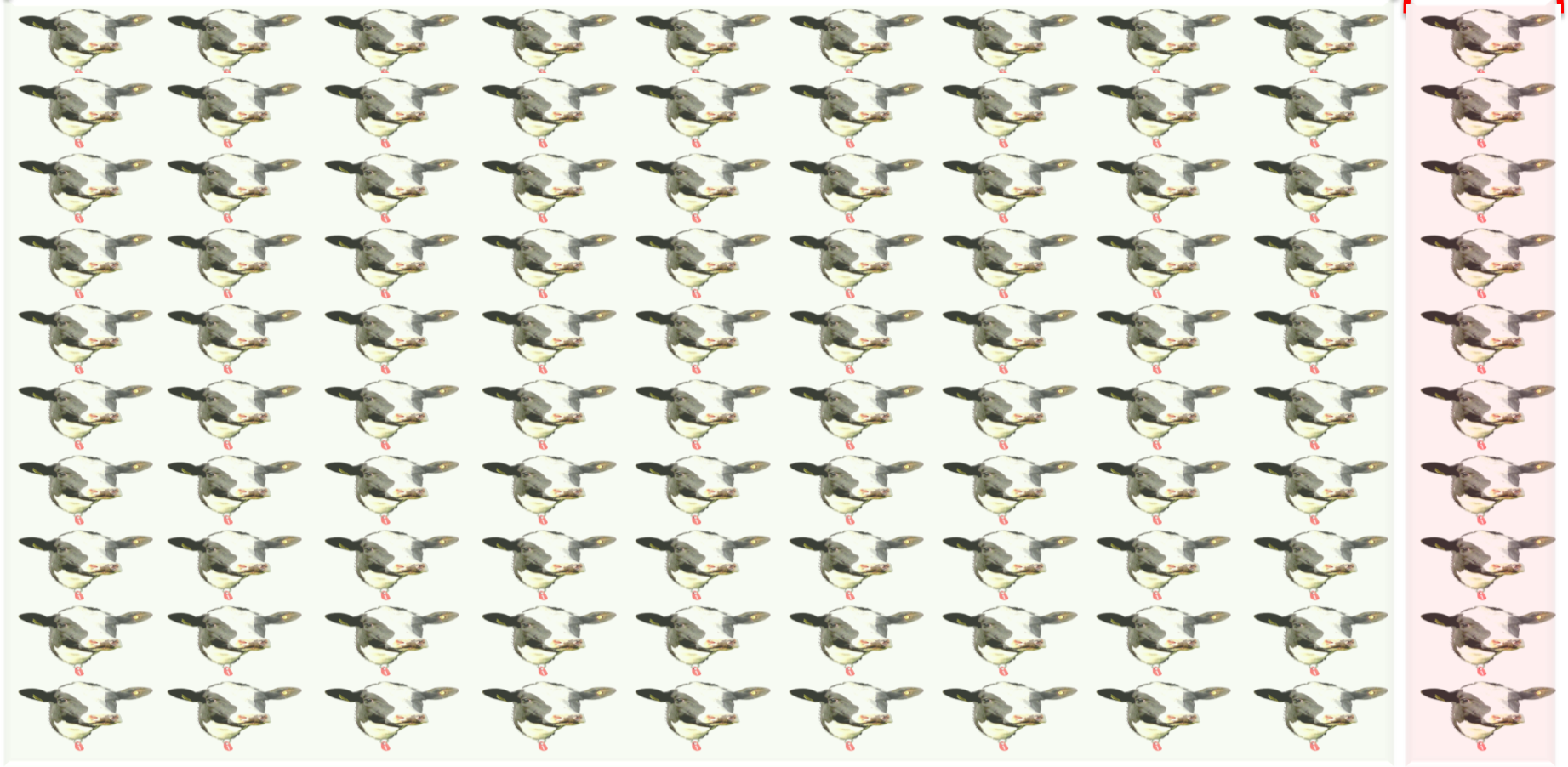


Example: 100 estrus events

How Many Alerts Coincide with an Actual Event?

90 Alerts for Cows Actually in Heat

10 Alerts for Cows Not in Heat



Example: 100 estrus events

Sensitivity/Specificity Battle

- ↑ Sensitivity by lowering threshold, BUT…

  ↓ Specificity (more false positives)

- ↑ Specificity by raising threshold, BUT…

  ↓ Sensitivity (more missed events)

- Trade off between the two

What's the Sweet Spot?

- Cost of missed event
  - High for estrus
  - Lower for diseases?
- Cost of false positive
  - Low for estrus
  - High for mastitis
- Farm dependent

Economic Considerations

- Need to do investment analysis
- Not one size fits all
- Economic benefits observed quickest for heat detection/reproduction
- If you don’t do anything with the information, it was useless
- Systems that measure multiple parameters make most sense
- Systems with low fixed costs work best for small farms

Tabs organize information

Introduction | Farm Informati... | Repro Managem... | Technology 1 | Technology 2 | Technology 3 | Results

Investment Analysis of Heat Detection Technologies

Description and instructions for user

Heat detection is a major concern on many dairies today.

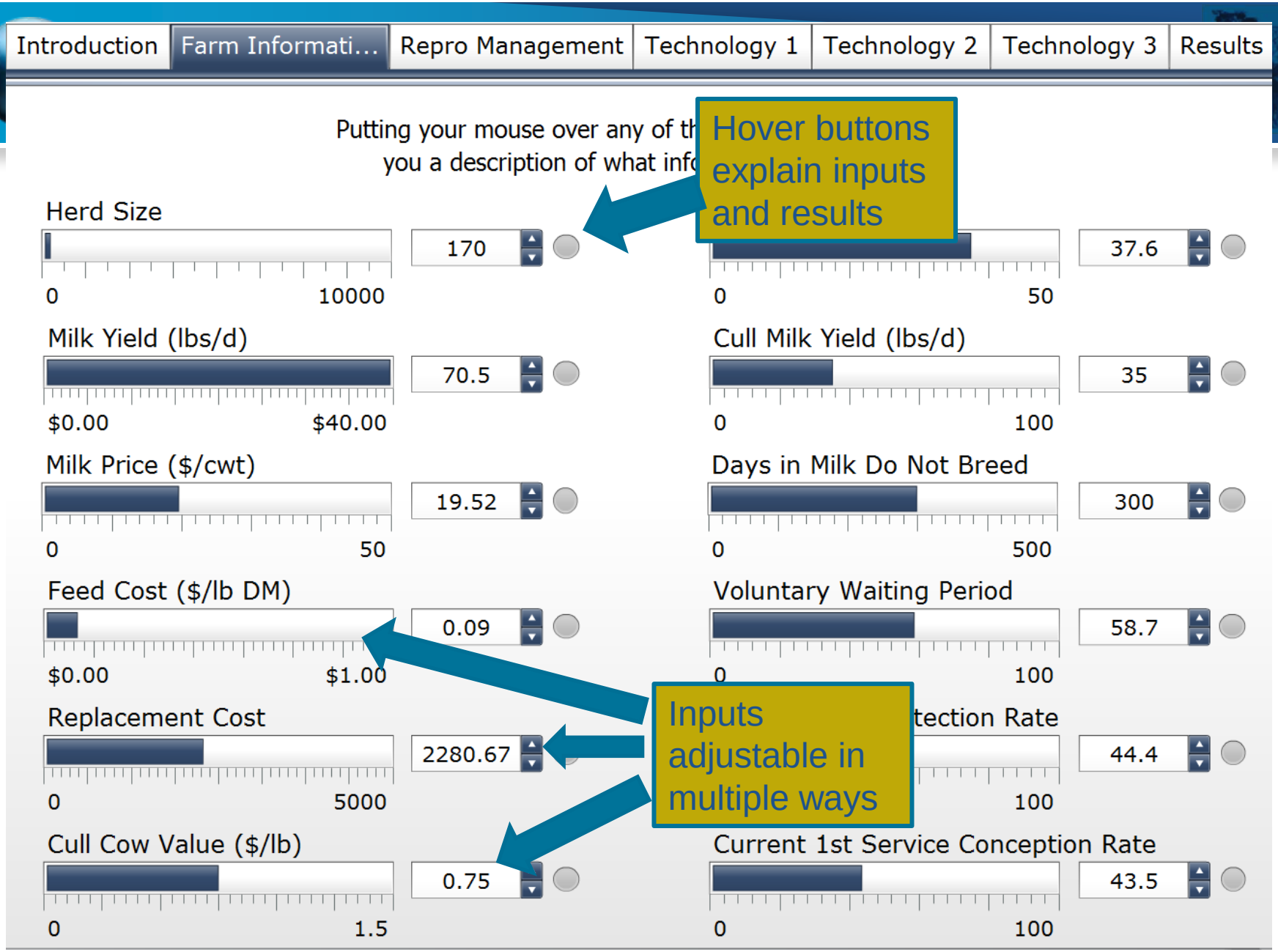
, technologies used to monitor activity
nd other cow parameters have been
to manage heat detection.

This net present value tool can be used to compare up to 3 different heat detection technologies in order to determine which might work best economically on a specific dairy.

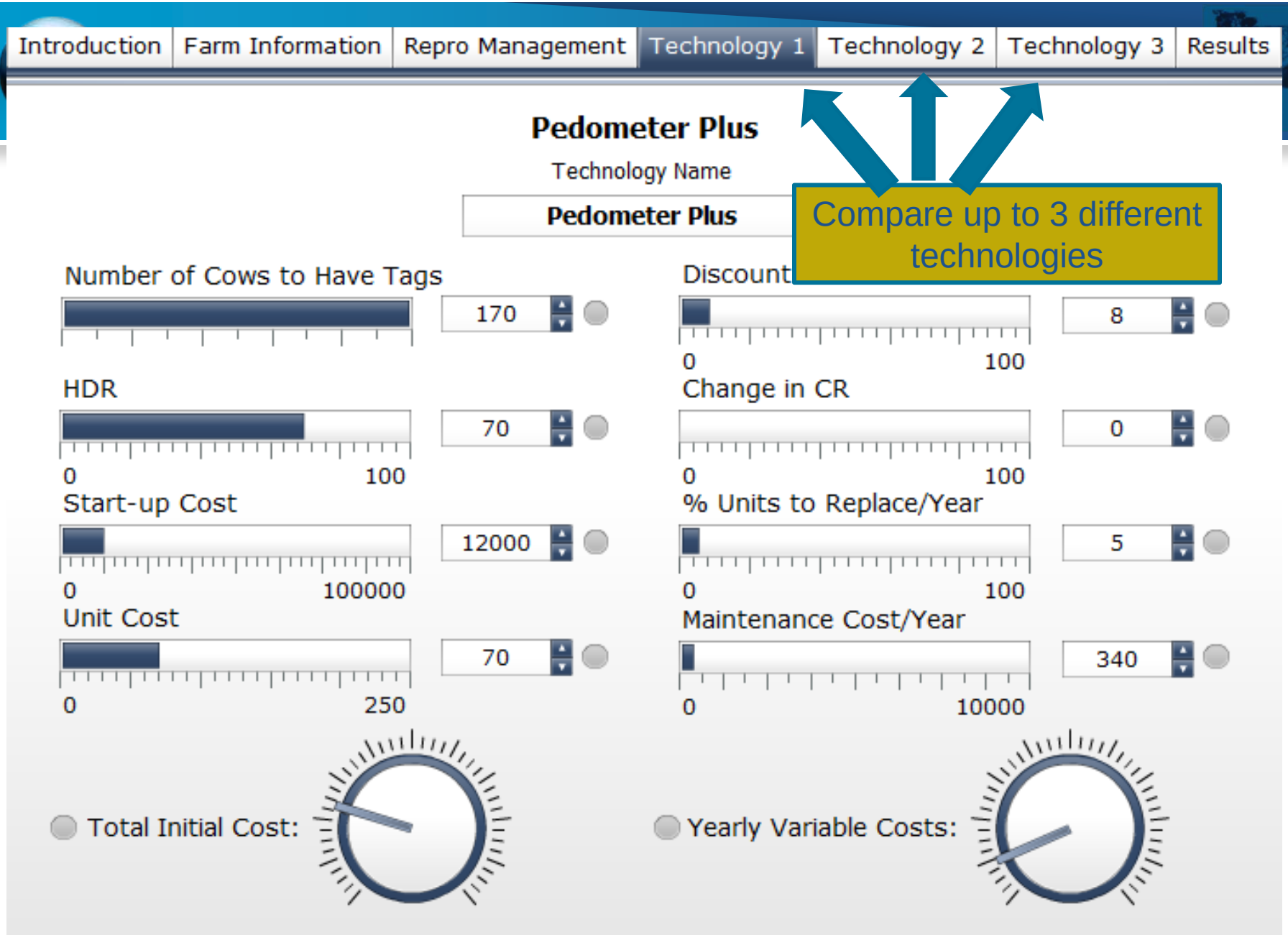
To use, change herd and technology information in the input tabs and then review the outcome in the "Results" and "Before vs. After" tabs.

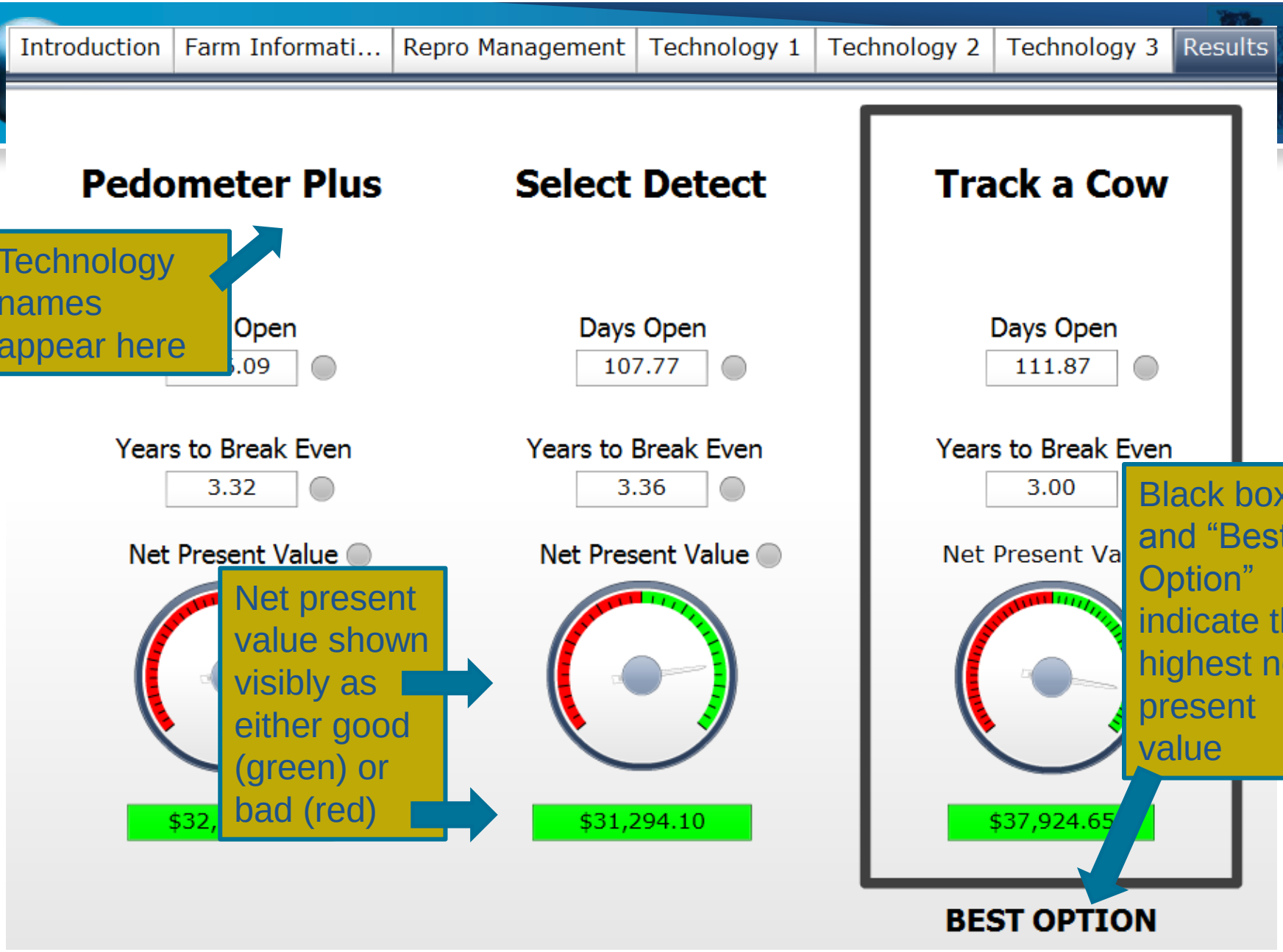
Developed by Karmella Dolecheck and Jeffrey Bewley
Animal & Food Sciences Department
University of Kentucky College of Agriculture

UK UNIVERSITY OF KENTUCKY College of Agriculture
PRECISION DAIRY & COW ENVIRONMENT CONSORTIUM



www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies Karmella Dolecheck et al.

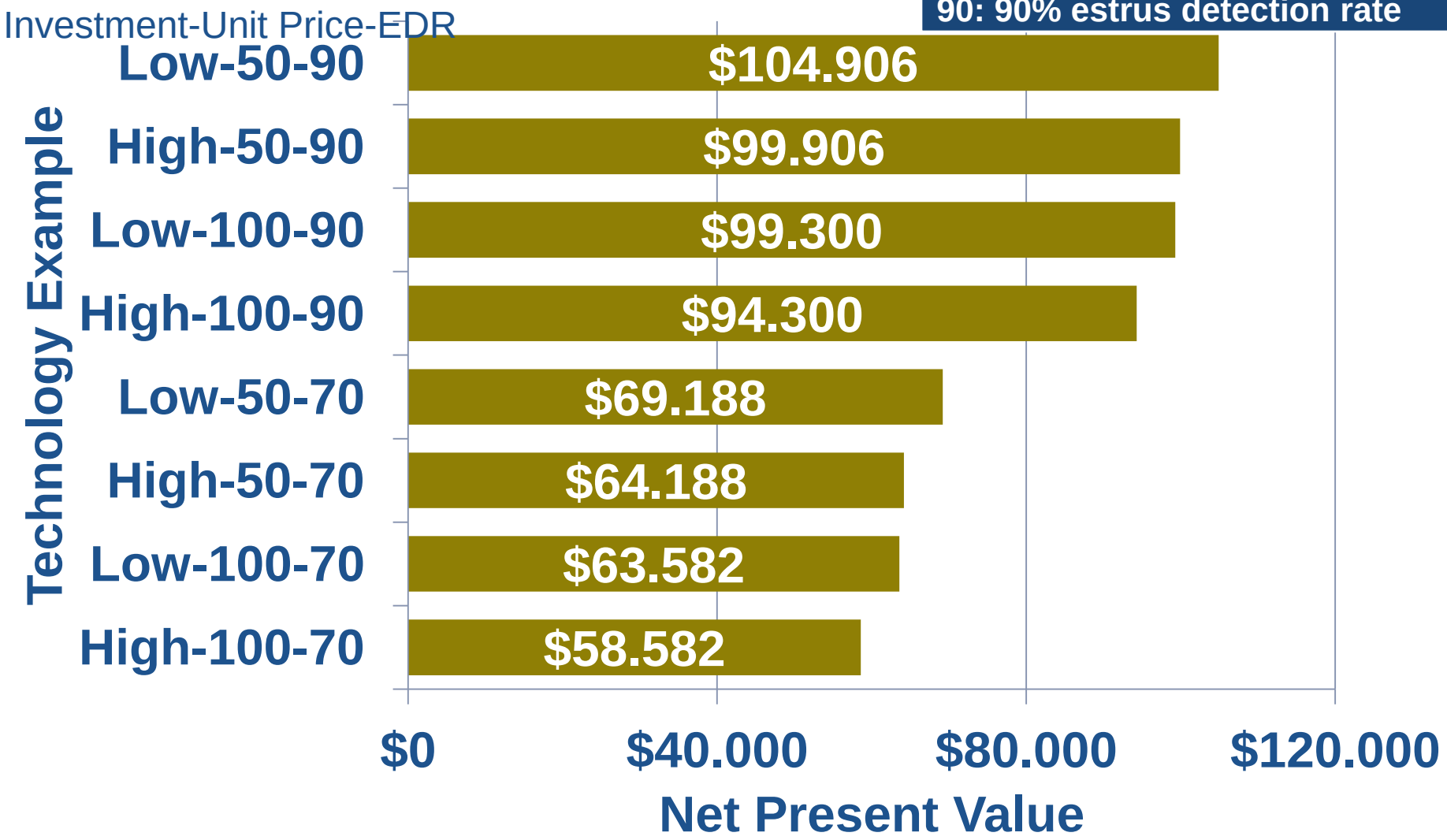

Introduction
Farm Information
Repro Management
Technology 1
Technology 2
Technology 3
Results
Pedometer Plus
Technology Name
Pedometer Plus
Compare up to 3 different technologies
Number of Cows to Have Tags
170
Discount
8
0
100
HDR
70
0
100
Change in CR
0
0
100
Start-up Cost
12000
0
100000
% Units to Replace/Year
5
0
100
Unit Cost
70
0
250
Maintenance Cost/Year
340
0
10000
Total Initial Cost:
Yearly Variable Costs:



www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies Karmella Dolecheck et al.

Example Analysis

Low: $5,000 initial investment
High: $10,000 initial investment
50: $50 unit price
100: $100 unit price
70: 70% estrus detection rate
90: 90% estrus detection rate



Karmella Dolecheck et al.

Technology Pitfalls

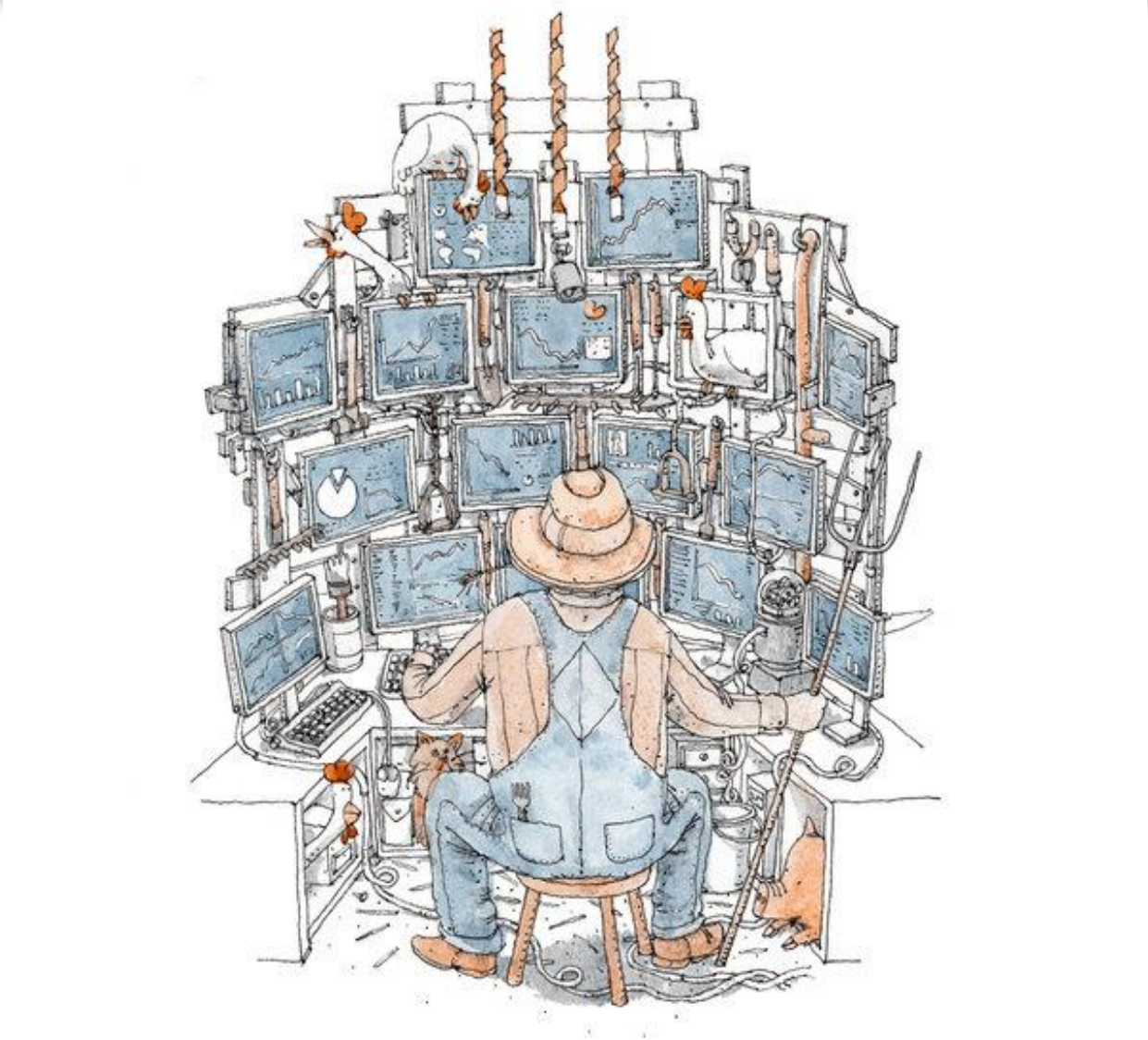
- “Plug and play,” “Plug and pray,” or “Plug and pay”
- Technologies go to market too quickly
- Not fully-developed
- Software not user-friendly
- Developed independently without consideration of integration with other technologies and farmer work patterns

Technology Pitfalls

- Too many single measurement systems
- Lack of large-scale commercial field trials and demonstrations
- Technology marketed without adequate interpretation of biological significance of data
- Information provided with no clear action plan

- Be prepared for little things to go wrong
- Be careful with early stage technologies
- Need a few months to learn how to use data
- Data integration is challenging

UK Herdsman Office



From Purdue to Poor Due

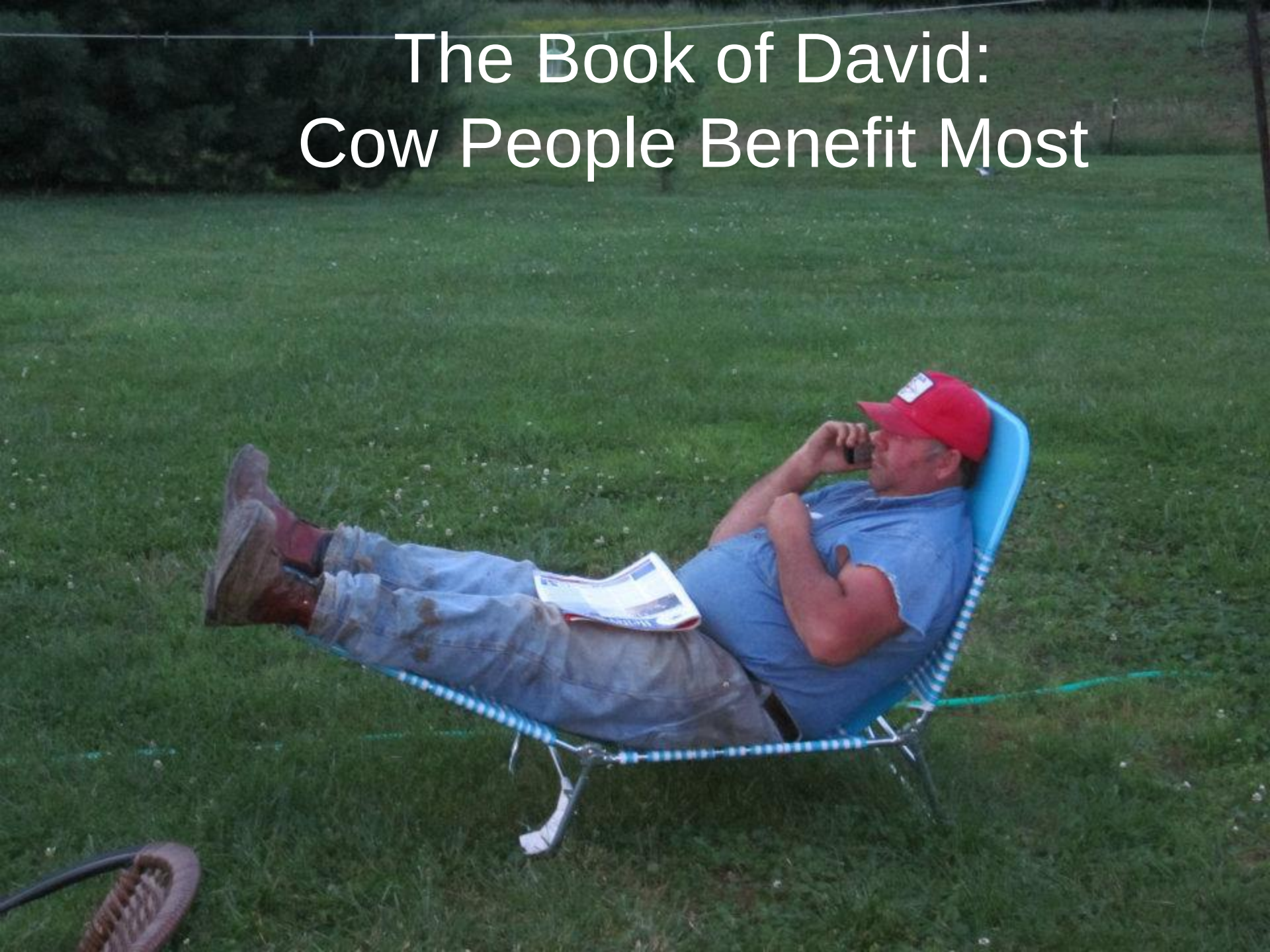
PURDUE
UNIVERSITY

Did I get the wrong PhD?

Sociological Factors

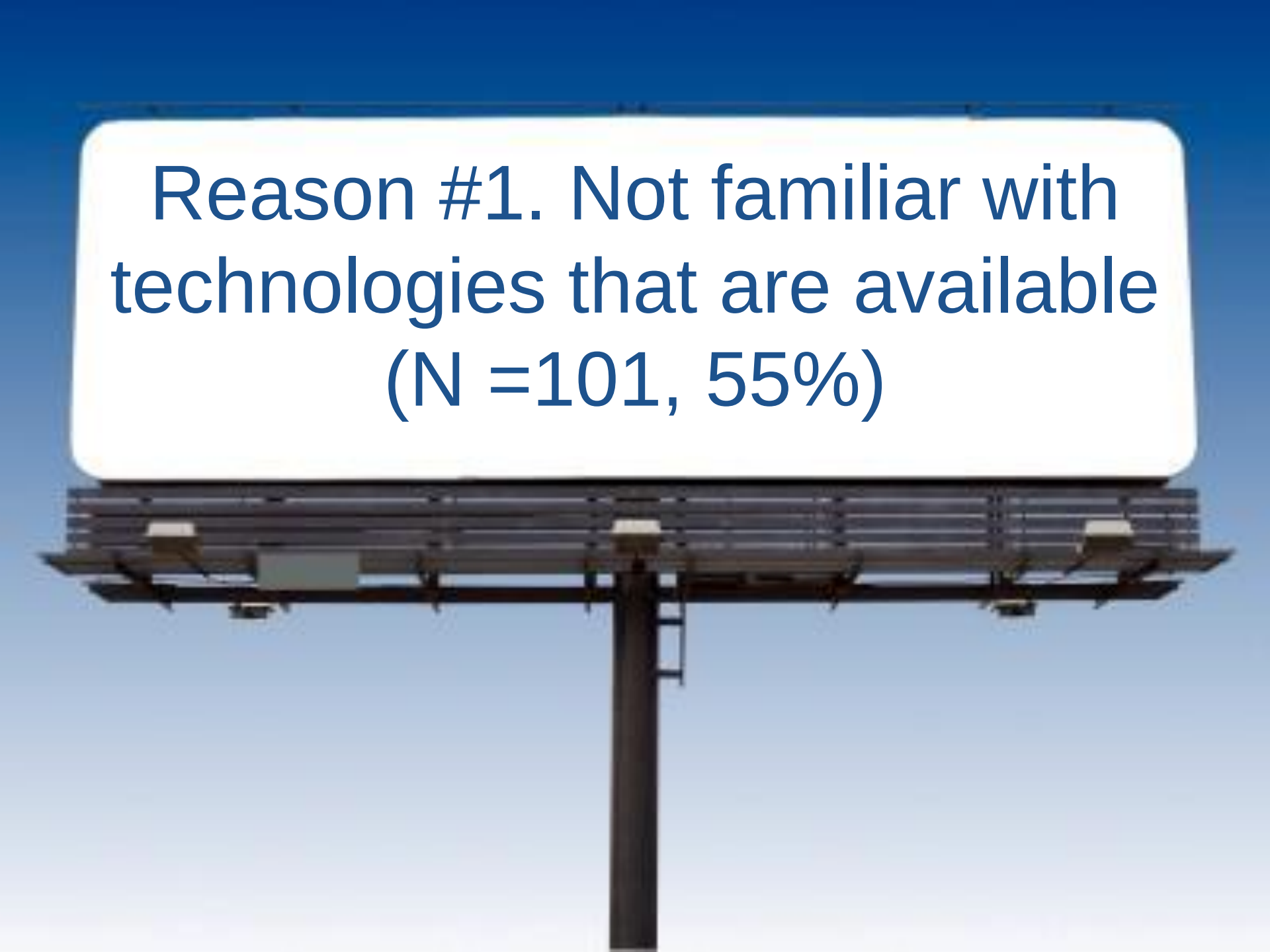
- Labor savings and potential quality of life improvements affect investment decisions (Cantin, 2008)
- Insufficient market research
- Farmers overwhelmed by too many options (Banhazi and Black, 2009)
  - Which technology should I adopt?
  - End up adopting those that are interesting or where they have an expertise
  - Not necessarily the most profitable ones

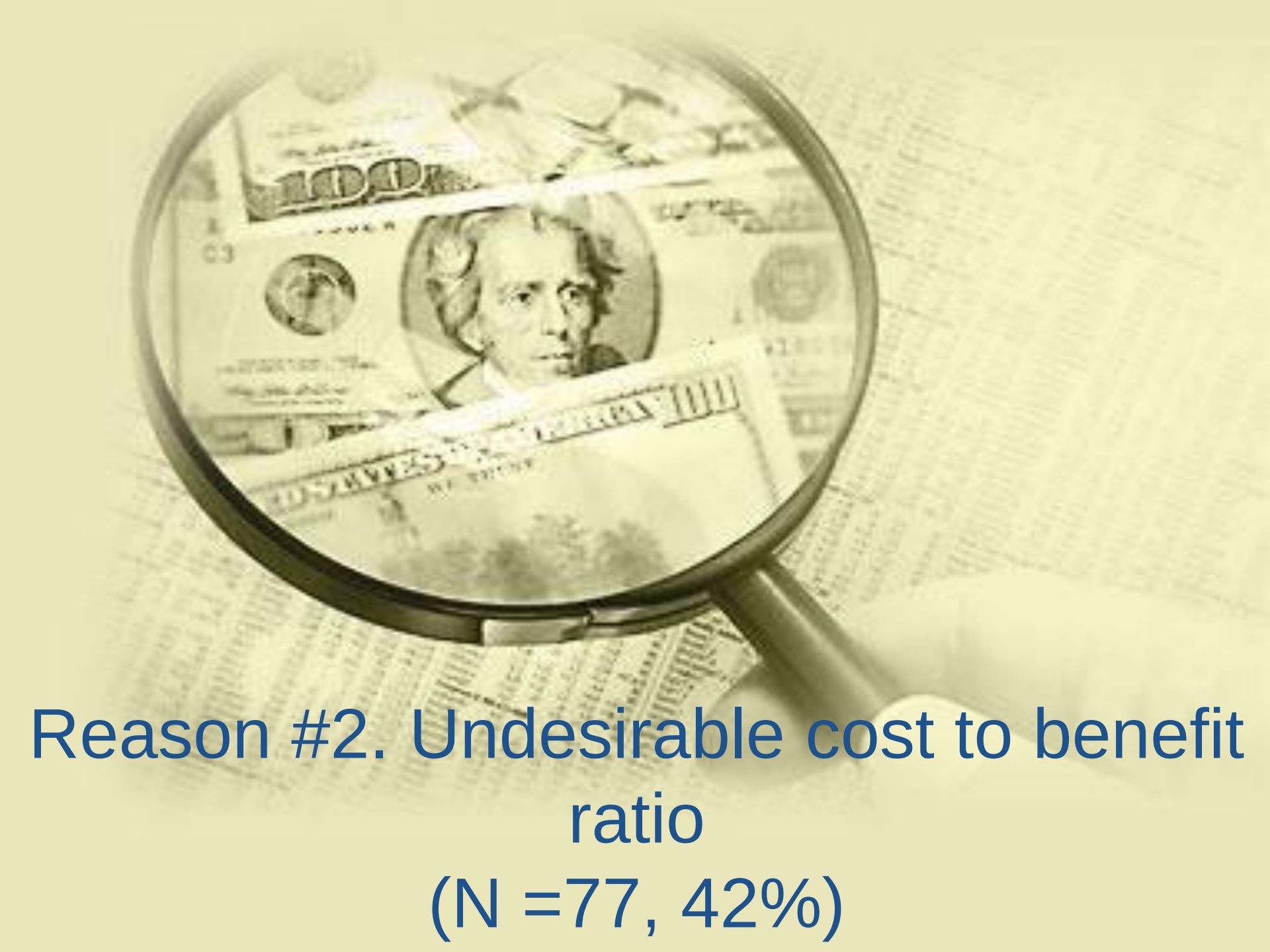
The Book of David:
Cow People Benefit Most



Why Have Adoption Rates Been Slow?

Rebecca Russell

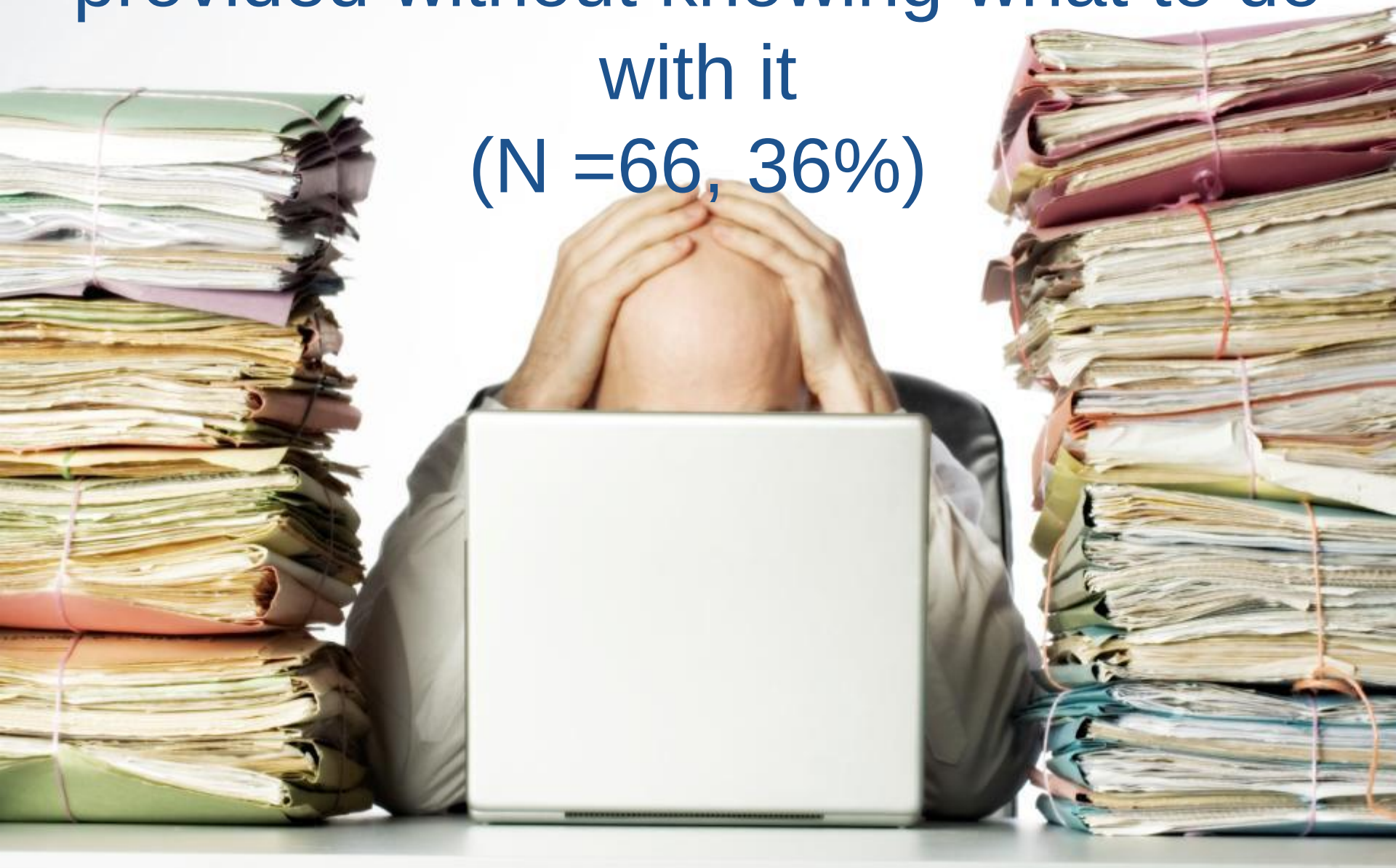

Reason #1. Not familiar with technologies that are available (N =101, 55%)



Reason #2. Undesirable cost to benefit ratio

(N =77, 42%)

Reason #3. Too much information provided without knowing what to do with it (N =66, 36%)



Reason #4. Not enough time to spend on technology (N =56, 30%)

Reason #5. Lack of perceived economic value (N =55, 30%)

Reason #6. Too Difficult or Complex to Use (N =53, 29%)

Reason #7. Poor technical support/training (N =52, 28%)

Reason #8. Better alternatives/easier to accomplish manually (N =43, 23%)

Reason #9. Failure in fitting with farmer patterns of work (N =40, 22%)

Reason #10. Fear of technology/computer illiteracy (N =39, 21%)

Reason #11. Not reliable or flexible enough (N =33, 18%)

Reason #99. Wrong College Degree (N =289, 100%)

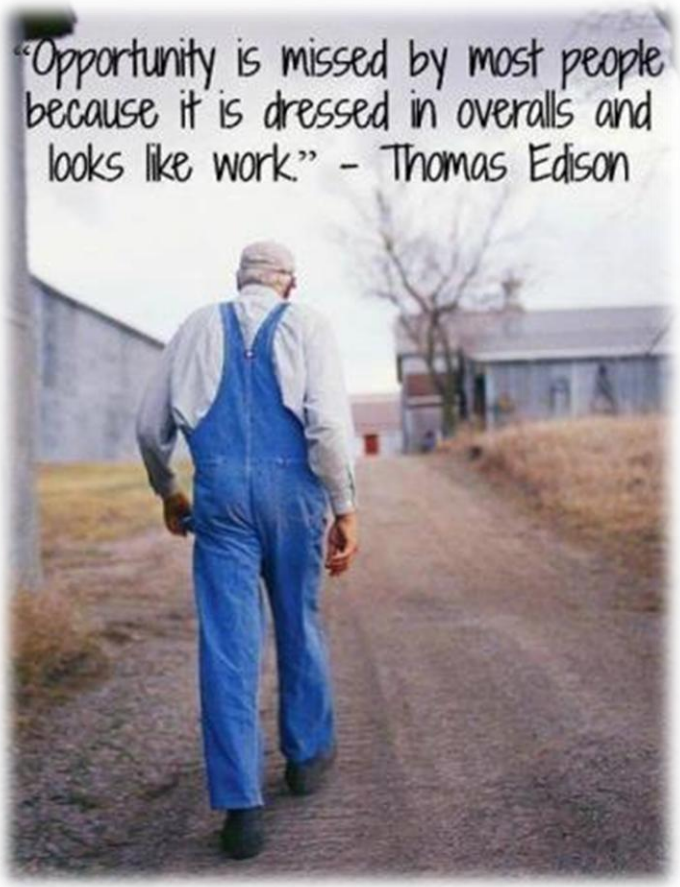
Customer Service is Key

- More important than the gadget
- Computer literacy
- Not engineers
- Time limits
- Failure of hardware and software

"Can I return these?...They're nice and all, but they just scare the snot out of me."

Cautious Optimism

- Critics say it is too technical or challenging
- We are just beginning
- Precision Dairy won't change cows or people
- Will change how they work together
- Improve farmer and cow well-being



Path to Success

- Continue this rapid innovation
- Maintain realistic expectations
- Respond to farmer questions and feedback
- Never lose sight of the cow
- Educate, communicate, and collaborate

Future Vision

- New era in dairy management
- Exciting technologies
- New ways of monitoring and improving animal health, well-being, and reproduction
- Analytics as competitive advantage
- Economics and human factors are key

Questions?

Jeffrey Bewley, PhD, PAS
407 W.P. Garrigus Building
Lexington, KY 40546-0215
Office: 859-257-7543
Cell: 859-699-2998
Fax: 859-257-7537
jbewley@uky.edu
www.bewleydairy.com