HOW SENSOR DEVICES AND AUTOMATION ARE CHANGING DAIRY DATA FOR GOOD

CDCB Industry Forum
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Steven Sievert
Manager, Quality Certification Services Inc.
Technical Director, National DHIA
Chair, ICAR Subcommittee for Recording and Sampling Devices
Chair, ICAR Sensor Devices Task Force

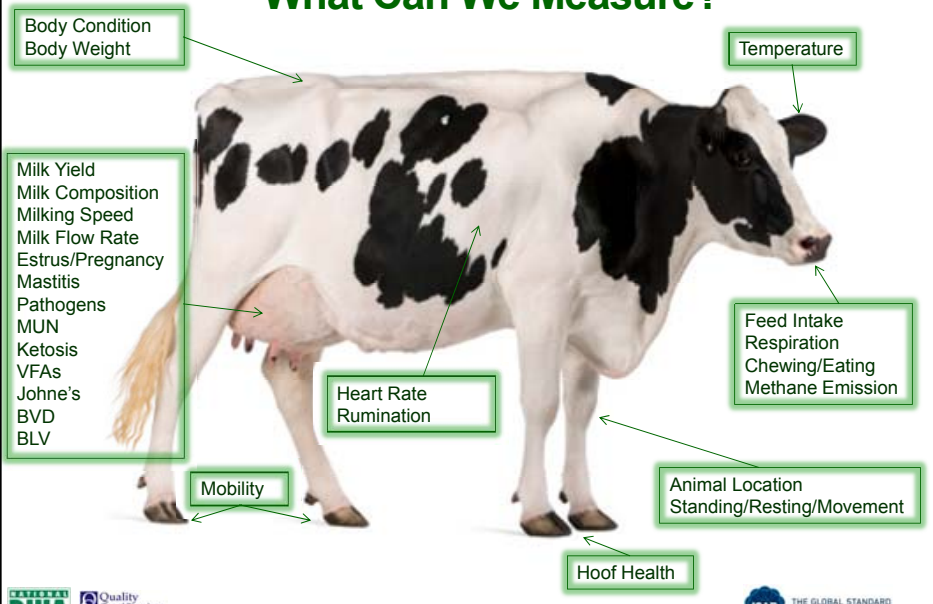
Opportunities & Challenges with Data from Sensor Devices

Livestock are ideal candidates for repeated measures – **What can I tell you?**

Producers are saying I made the investment - **How are you going to use my farm/herd data?**

Recording organizations are looking for guidance – **What do we do?**

What Can We Measure?



Current State of Sensor Technology

- Technology is Improving and Changing Rapidly and Easily Adopted by Producers
- Many Isolated Packages without Integration or Linkage
- Sensor Users Follow a "Community of Practices" – no True Standards or SOPs
- Validation, Maintenance, and Calibration Protocols are Missing
- There is System Bias and Individual Sensor Bias

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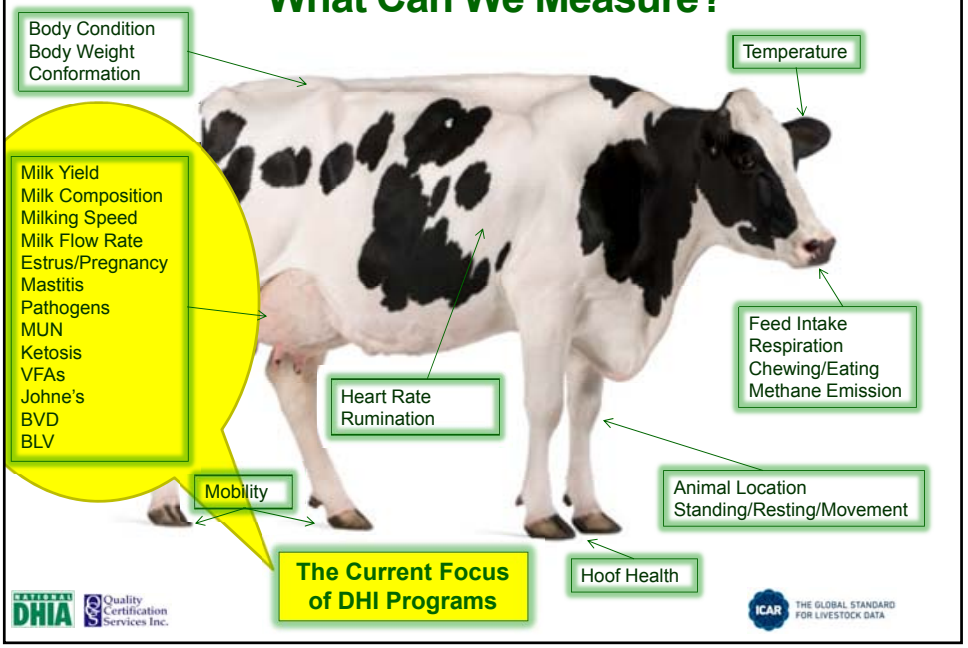
What Can We Measure?



Animal ID is More Important Than Ever

- The "official ID" of a cow most likely will not be the same as ID associated with sensor measures
- Cows will have multiple IDs over their lifetime
- Cows will have multiple IDs on their body at once
- Databases will need to have protocols for ID cross-referencing and validation
- DHI will need protocols for on-farm validation of the ID system and for data transfer/custody
- ID issues may be major source of error in data

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Needs of the Industry & Producer

Approval, Calibration & Best Use Protocols

Sensor Approval and Validation

- Development of guidelines for sensors
- Testing & validation protocols
- Co-innovation & cooperation with manufacturers

Routine Procedures & Best Practices

- Installation protocols
- Routine calibration and monitoring procedures
- Development of best practices for recording organizations

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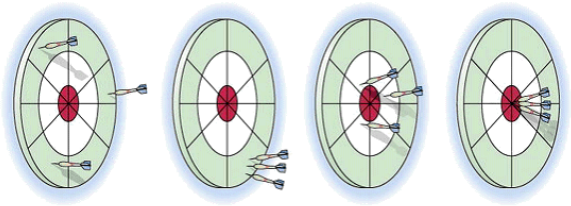
Accuracy & Precision



(a) Low accuracy Low precision | (b) Low accuracy High precision | (c) High accuracy Low precision | (d) High accuracy High precision

- **Cannot simply assume that you can be less accurate in measurement just because you have more data observations**
- Improve accuracy by calibration & design
- Improve precision by quality control
- **What are the accuracy & precision compared to the "gold standard" for the industry?**
- Cannot simply assume that accuracy & precision are acceptable when compared to other measures on the farm

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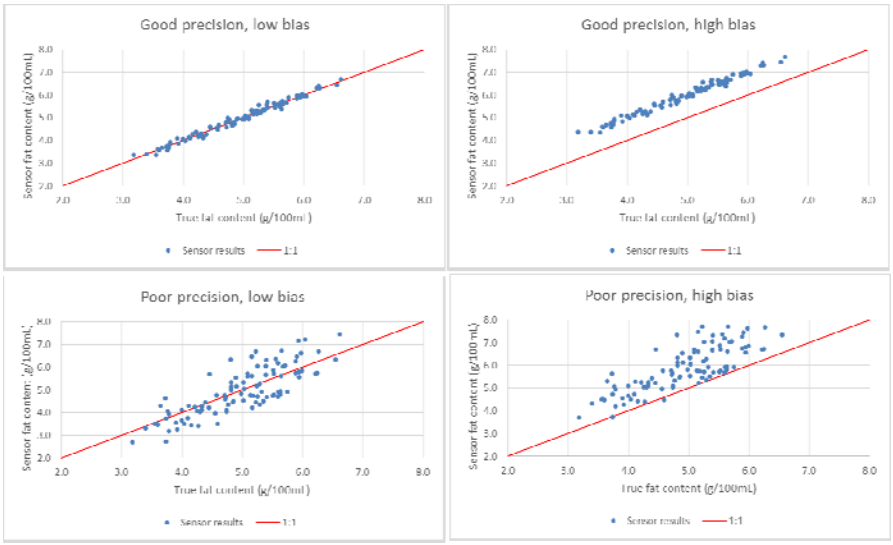
Accuracy & Precision of Four Fat Sensors



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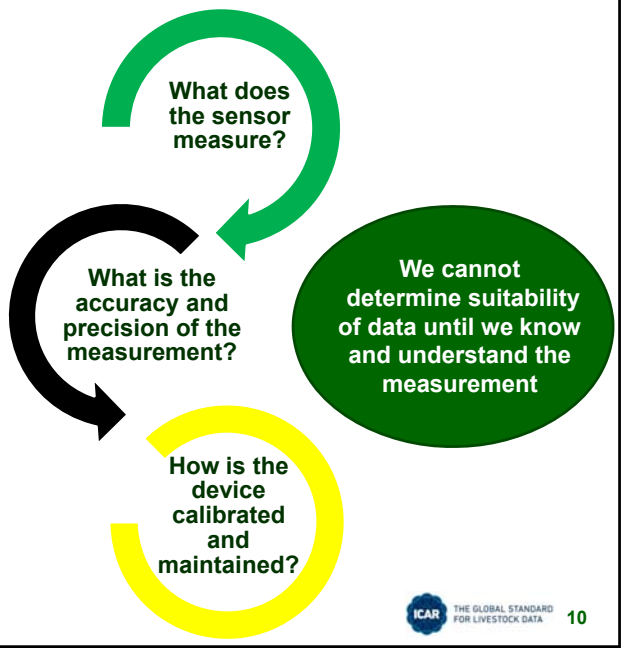
Understanding Sensor Devices Helps Determine Value of Sensor Data



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What are We Measuring?

Multiple Indicators of Mastitis or Milk Quality

- Automated CMT/WMT
- Electrical conductivity
- L-lactate dehydrogenase
- N-acetyl-beta-D-glucosaminidase
- ATP luminescence
- Thermal imaging
- Visible, NIR, MIR spectroscopy

Milk quality measures are affected by sampling time, temperature, milk viscosity, calibration

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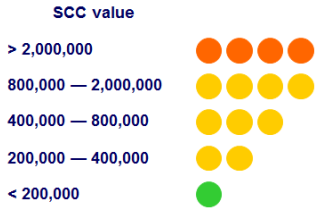
All SCC Values Are Not Equal

The Case of the CellSense Sensor

- Automated CMT Test
- Estimates SCC content at 45 seconds into milking
- While correlated to total milk SCC, it is NOT the same
- Visual scale of probable SCC value
- Algorithm is based on calibration/adjustment based on DHI SCC values and/or adjustment to bulk tank SCC
- Each sensor has its own bias (positive or negative)
- Is there a system bias as well?



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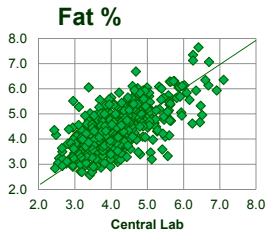
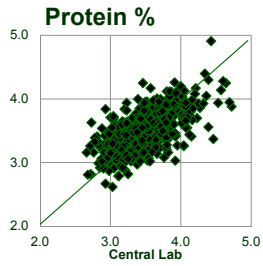
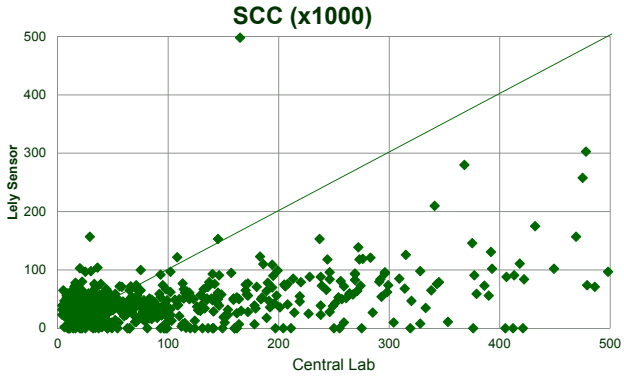
Comparing Lely Sensors & Central Lab Component Results



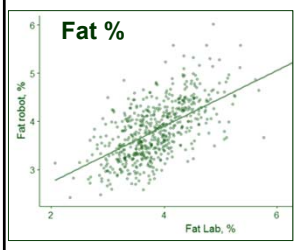


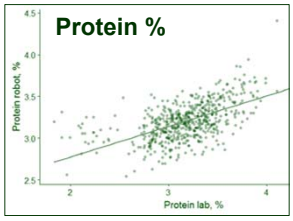


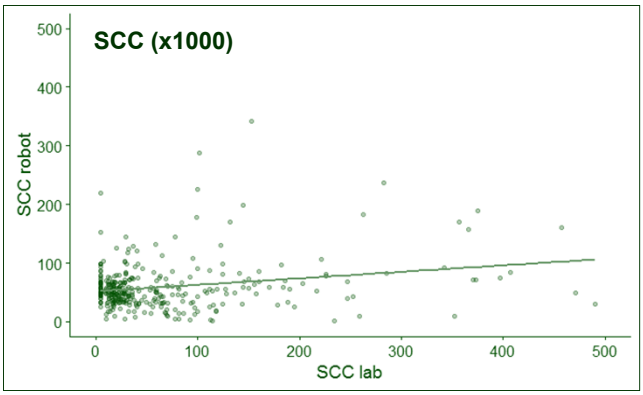
- Poor relationship for SCC, moderate for fat & true protein
- One measures representative sample of total milk and the other estimates at a point during milk letdown

Holsteins – 13 boxes –data courtesy of RYK (Denmark)

Lely Sensor – Valacta (Preliminary Comparison)



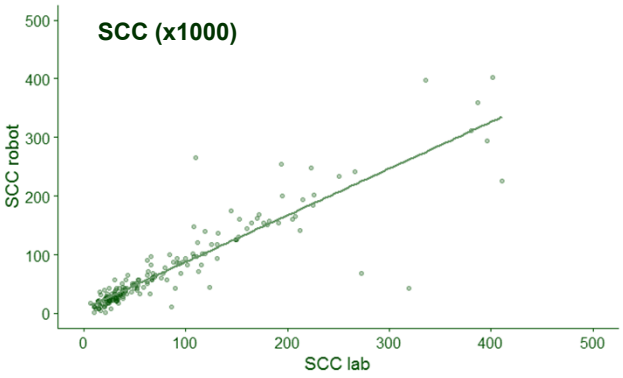




- Similar component relationships between on-farm sensors and central lab results in Quebec and Denmark
- Environmental effects– AMS settings/adjustments, milking settings, feeding programs may have influences

10 Lely dairies – preliminary data courtesy of Valacta (CA)

Preliminary Comparison of DeLaval OCC & Valacta SCC



- Strong relationship between sensor and central lab results for SCC
- Cannot make blanket assumption by milk harvest system
- Not all robotic systems are at the same level of accuracy or precision for each component

4 DeLaval VMS dairies – preliminary data courtesy of Valacta (CA)

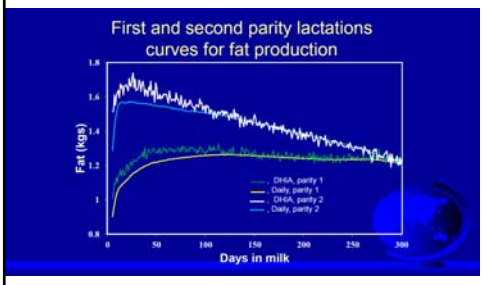
Using SCC Sensors

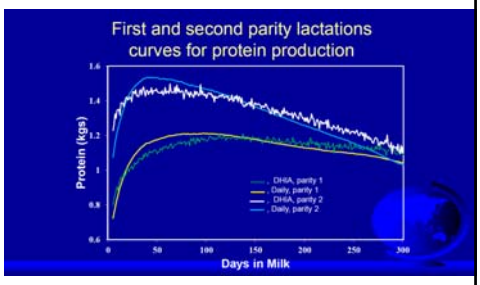
Most SCC sensors are intended for mastitis/milk quality management – not genetic evaluations

- Detect and monitor subclinical mastitis
- Manage bulk tank SCC
- Develop action list for cows to culture
- Identify cows for selective dry cow therapy
- Identify cows to cull

Our current data flow system cannot distinguish sources of SCC data – the need exists to capture source of data as well as reported value

Sensor Accuracy May Be Affected by Milk Flow





Accuracy is Not Constant Throughout Lactation

- Example of in-line analyzer compared to DHI lab results across the entire lactation
- In this case – underestimated fat yield & overestimated protein yield in the first 125 days of lactation
- Technology is improving but cannot simply accept results as this is the "best we can do presently"

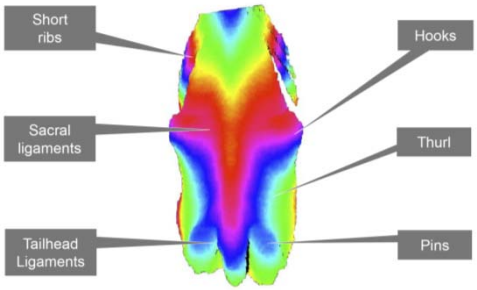
Potential New Streams of Data – Milking Speed

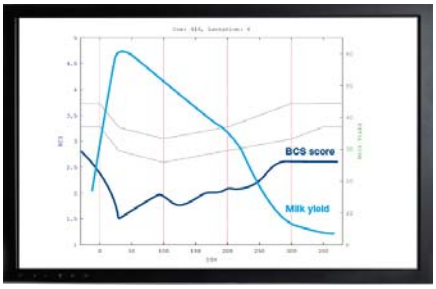
ID Performance Details, Count 132

Cow No.	Group No.	Transp. No. ♥ 1	Milk Yield	Corrected Yield	ID Time	Milk Start Time	Milk Dur.	MPC Address	Storage Position
900001	1	-	9.80	-	-	19:10:34	04:02:00	61	2
900001	1	-	12.20	-	-	19:05:07	05:38:00	78	1
900002	5		0.00	-	-	18:56:54	00:05:00		1
900002	5	-	15.60	-	-	19:02:12	05:47:00	55	2
900003	5	-	10.80	-	-	19:31:20	04:23:00	41	1
900003	5	-	11.30	-	-	19:43:24	04:50:00	75	2
900004	5	-	8.40	-	-	20:14:05	04:23:00	74	2
900004	5	-	13.60	-	-	19:49:36	05:07:00	64	1
900005	5	-	4.00	-	-	19:50:37	05:06:00	72	1
900005	5	-	11.50	-	-	20:35:30	05:21:00	58	2
900006	5	-	6.30	-	-	20:42:57	04:40:00	57	1
900006	5	-	8.90	-	-	20:46:53	04:45:00	88	2

- Different definitions of milking speed (kg/minute, yield over 300 seconds, etc.)
- Data exists and can be repackaged to for different needs
- Data used for on-farm management - cow grouping, parlor efficiency, system performance, milker (human) performance
- Data for genetic evaluations – percent milk in specified time frame or percent time in peak flow phase

New Streams of Data – Body Condition Scores





- Device approval/validation needed
- Repeatability & reproducibility are greater than human visual scoring
- Valuable information when combined with DIM, milk yield, health incidence data
- Standards for data capture/transfer – not possible in current data exchange formats

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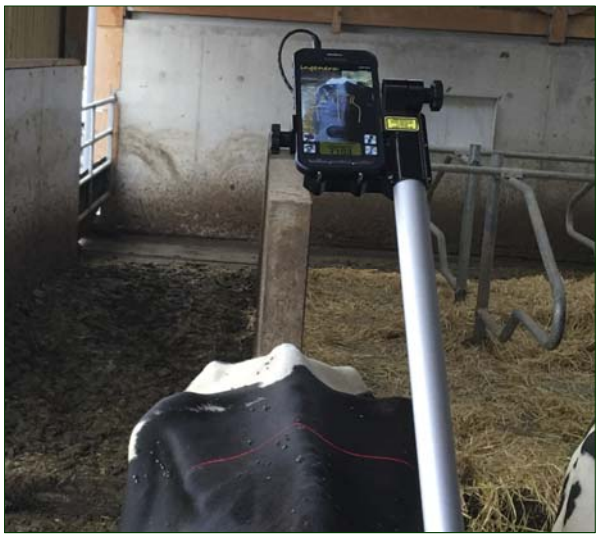
BCS, Weights & Linear Scores in One Device



- 3D Real-Time measurements of phenotypic conformation
- Versions for AMS, parlors, and non-confined cattle
- Fast & stress-free
- Multiple measures over lifetime of cow

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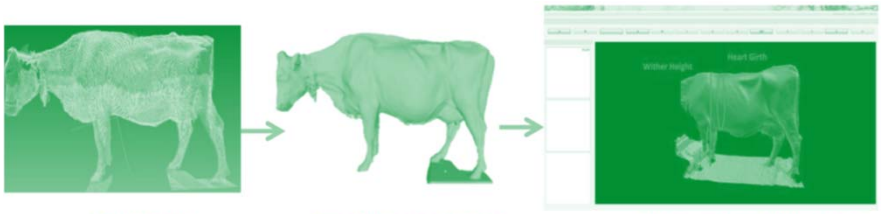
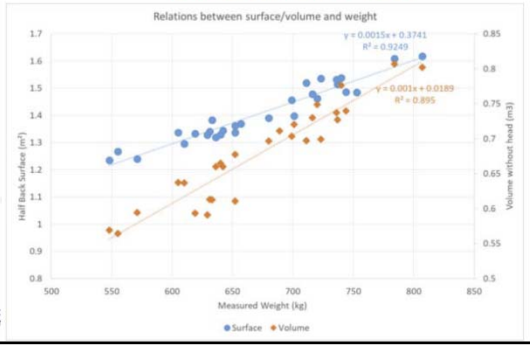
Whole Body Imaging



3D raw cloud

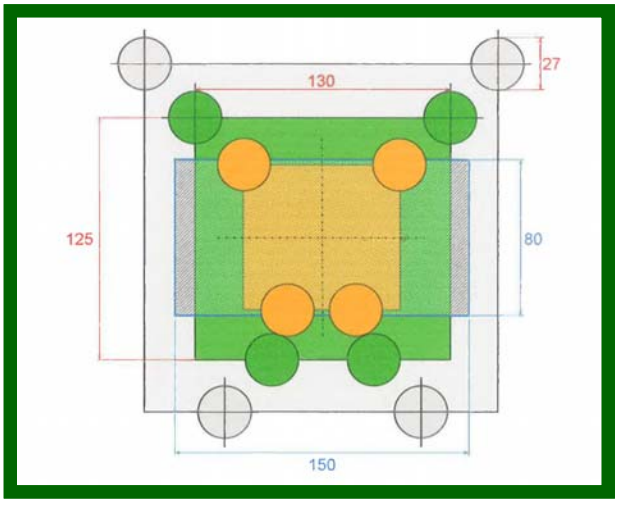
Smoothing and shape reconstruction on Meshlab®

Measures on Metrux2α®



- Linear measures
- Circumferences
- Surfaces
- Volumes

What About Robotic Teat Placement Sensors?



- Actual teat location based on successful attachment
- May or may not have teat shape, length or angle in data set
- Multiple measures over single lactation and over lifetime of cow
- Data can be used to potentially compute six teat placement traits
- Can we improve trait heritability?

Potential New Streams of Data – Activity

Motility & Activity

- **Can we use this data?**
- How do we use this data?
  - Animal Health & Welfare
  - Feed Efficiency
  - Benchmarking
- Need to define the measure(s)
- "Alert data" on local computers used for daily management decisions
- "Measured data" transfer to national databases for research, benchmarking, genetic evaluations

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The Illusion of Accuracy in Some Devices

Precision of Recording

4.2% vs. 4.22% vs. 4.222% (Milkfat)

181,000 vs 180,862 (SCC)

Values provided are the result of algorithm

Adjustment vs. Calibration

Adjusting to known value (i.e. BT SCC) is not the same as calibrating the device(s)

Adjustments make the data look better but don't increase accuracy – the individual device biases still exist in the system

Overpromising and Under Delivering Results to Dairy Producers with Certain Devices or Systems

Devices that Measure Multiple Parameters

How do we handle data where approval for one parameter exists but not for all parameters measured?

All data flows through interface and once data is in the system, it flows

Device Approval

Marketing vs. Testing & Approval

Working with [National DHIA] is not the same as [National DHIA]-approved

Benefit of ICAR testing & certification

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What Do We Need to Capture?

Define the parameter and recording period – for example…

- 7 consecutive days - BCS
- 30 consecutive milkings - SCC

What else do we need to capture?

- animal ID
- date/time stamp
- parlor/stall location where applicable
- sensor device name/type
- define other linked data or traits

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Is the Data Real?

Handling of missing data points

- How are missing points estimated?
- Mean of actual data only?

Outlier handling, exclusion, smoothing

System bias or system adjustment?

Range of accurate measurement

Evaluation of algorithm

- Test data set to send through system algorithm to validate output?
- Protecting IP is a consideration

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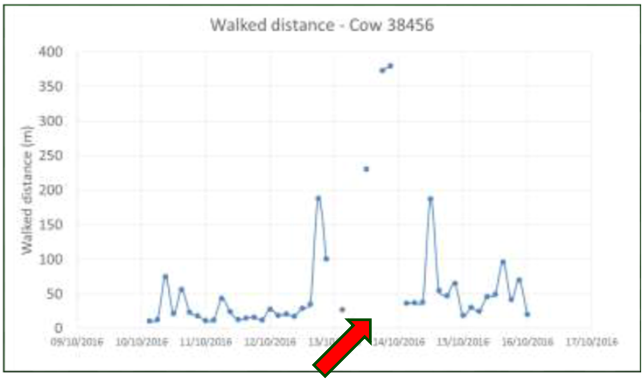
Complete, Connected, & Credible Data

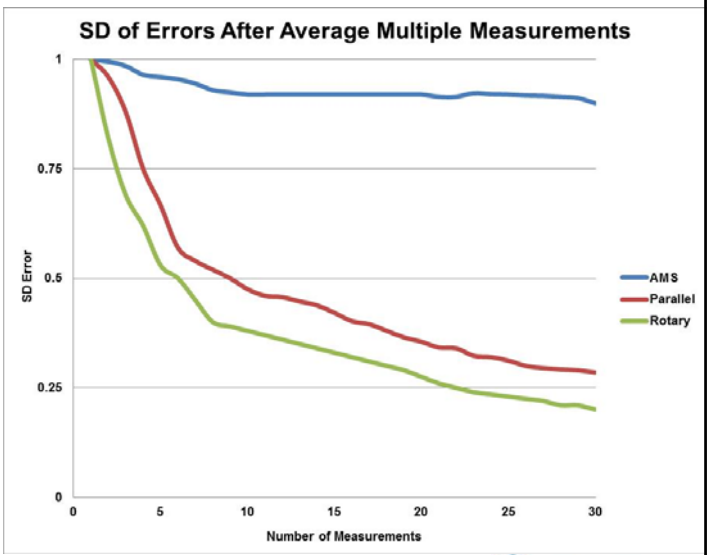


Gaps in data observations

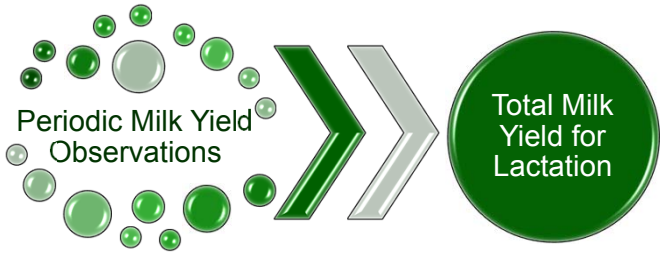
- How is the missing data computed?
- Estimates based on previous observations?
- Mean values without missing data?
- Affects the quality of data entering the system

Cumulative Effect of Sensor Errors

More observations are not the answer in all milk parlor configurations



Merging Multiple Streams of the Same Data



- **Producer may contribute information for the same parameter from different measuring devices**
- **Need to capture not only data point(s) but also source of the data**

How will we value each data point?
How will we value the complete record?
What information will we deliver?

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Data Capture & Flow Challenges

- Quality of LAN or Internet Connection at Dairy
- Many Different Versions of Software on Dairy – Updates Not Installed
- Frequent Updates of Milking System Software Creating Data Field Errors
- Random or Arbitrary Data Fields Created by Dairyman
- Lack of Real-Time Connection – May Only Be Daily or Weekly
- System is Too Complex/Labor Intensive for Dairy
- Inconsistent Data Definitions
- Data Quality – Missing or Incomplete
- ID Truncation/Translation/Cross-Referencing

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Needs for Data to Flow

Data Source, String ID, and Weighting

Capture Data Source

- Need to not only record the value but also the device that provides the value
- Record the number of measurements
- Need to be able to have more than one source of the same measure

Expand Testing Characteristics to Strings

- Current data exchange has one description per herd code
- Need to define data source and measurements by string/pen
- Cannot lose ability to move cows between strings

Weighting of Data Points

- Classes of data – will sensor data be treated as a separate class similar to how we treat supervised and owner-sampler data?
- Integration of data from multiple sources?

How Will We Value Sensor Data?

The Same Parameter May Be Estimated by Different Methods with Different Data Values Assigned for Each Method

Equivalency to Traditional Test Day Data
- Define parameters that approximate the accuracy and precision of traditional milk recording parameters like milk yield or composition

Separate Classes of Data
- Currently A & B Test Types – will we have a test type or class for specific sensor data

Weighting of Data
- Data collection rating system that puts relative weight on data type, collection interval, and parameters measured

Use Validated Data Directly
- New parameters may deliver data with acceptable accuracy and precision and the data is used with minimal editing

Exclusion of Certain Data
- Results from specific parameters may be deemed unsuitable for herd recording programs at the present time

Final Thoughts and Discussion Points

- Opportunities and challenges exist to capture new data observations from sensor devices.
- Industry needs to evaluate the opportunity of integrating sensor data based on research as each sensor is unique in deliverable data both in accuracy and precision.
- Investment and programming by all industry segments will be needed to capture not only data, but source and quality to assure appropriate use.
- Data delivery for management and health decisions will be the primary driver as opposed to data for genetic evaluations and research.
- Will need a balance of cooperation and competition – COOPETITION