INFORMATION FROM AUTOMATION (AMS/SENSOR DEVICES) RELEVANT FOR UDDER HEALTH MONITORING & IMPROVEMENT PROGRAMS

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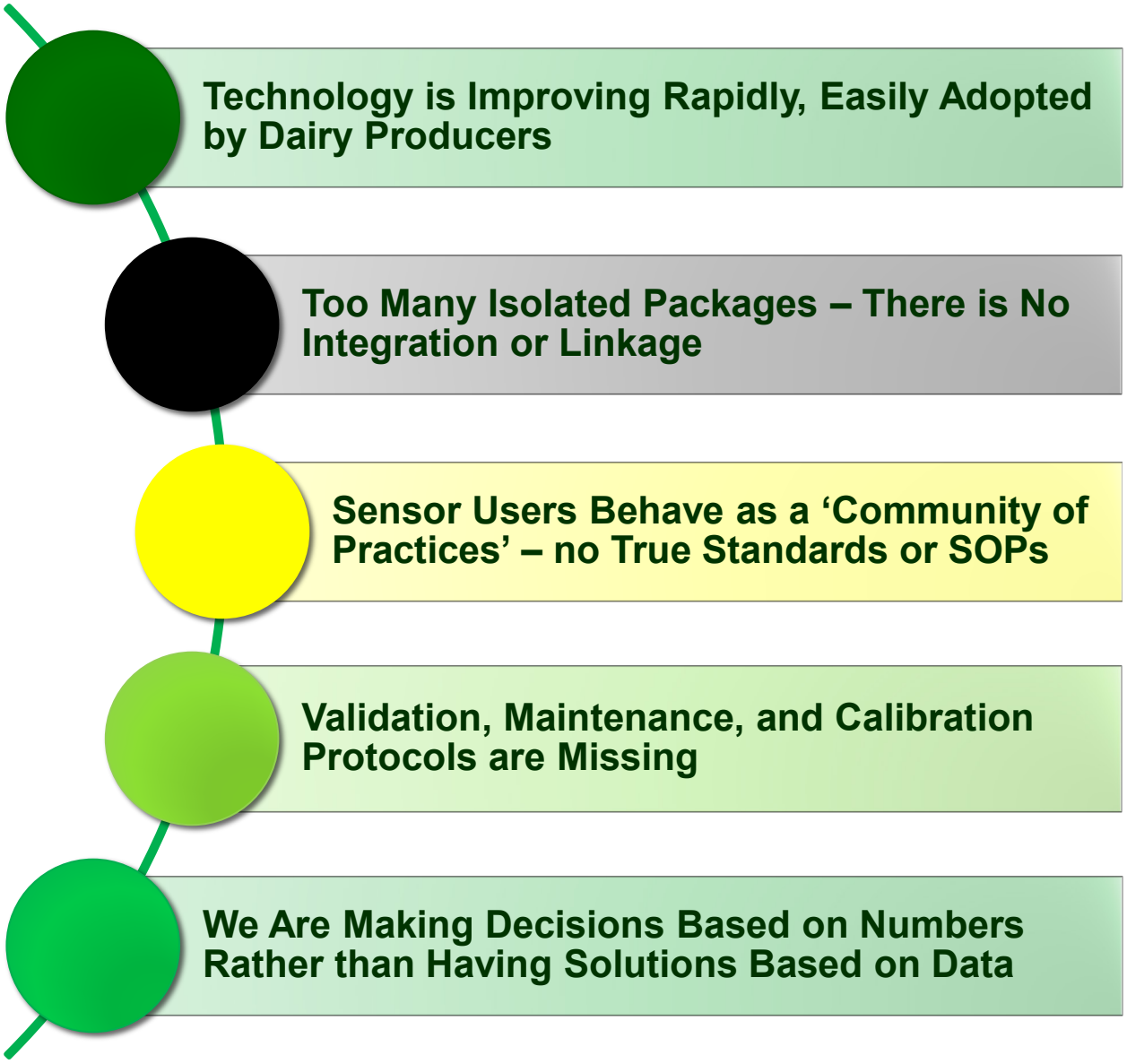
Current State of Sensor Technology

What is the Industry Telling Us?



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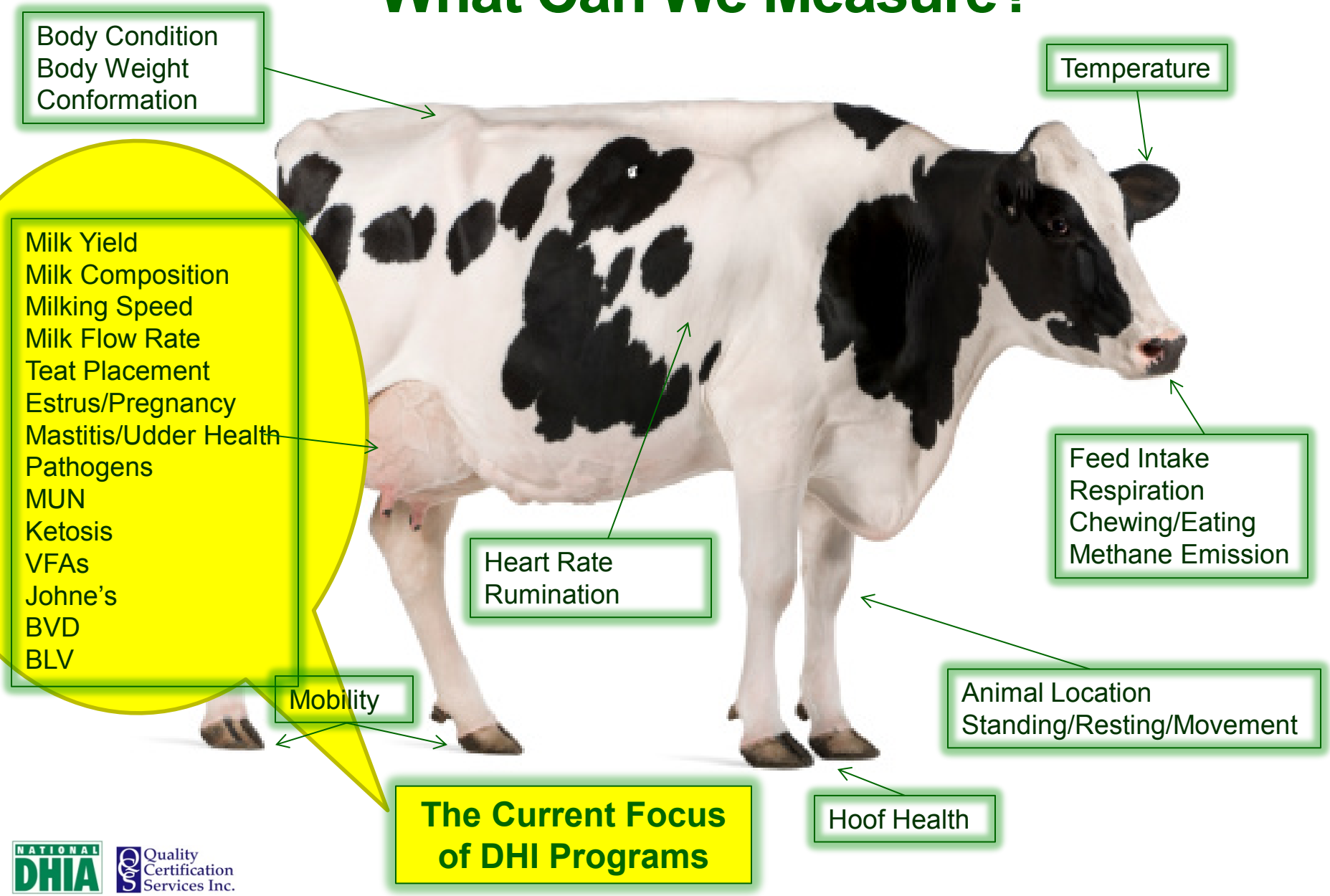
What Can We Measure?



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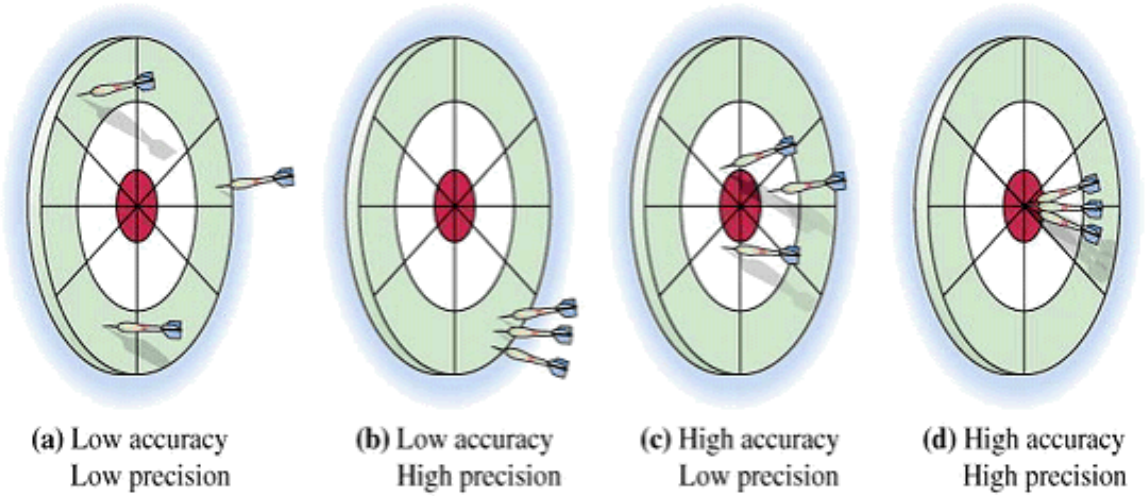
Accuracy & Precision



- **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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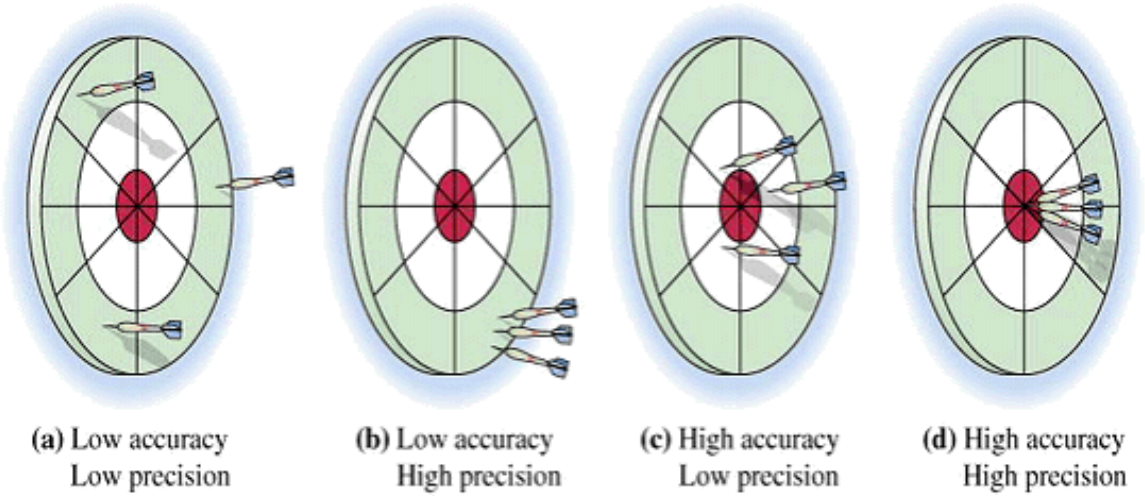
Accuracy & Precision



- **Some traits need high accuracy & high precision**
  - Milking speed, body weight
- **Some traits high accuracy & lower precision is okay**
  - SCC, fat, protein
- **Some traits lower accuracy & high precision is ideal**
  - Body condition scores, activity measurements

Multiple Ways to Classify Sensor Data

Management Data
- Yield
- SCC
- Milking Speed
- Feed Efficiency

Animal Health Data
- Locomotion
- Reproduction
- Disease
- BCS/Weight

Animal Welfare Data
- Activity
- Mobility
- Eating, Resting
- Heat Stress

Data for Genetic Evaluations

Different Needs for Accuracy & Precision

Data Linked to Direct Farm Payments
- Yield
- Fat, Protein
- SCC

Alarm Data
- Heat Detection
- SCC
- Locomotion
- Location

Yes/No Data
- Pregnancy
- Disease

Trend Data
- BCS/Weight
- Milk Flow/Speed
- Feed Efficiency
- Eating, Resting

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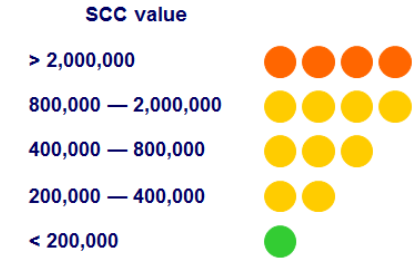
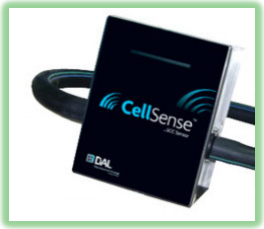
What are We Measuring?

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



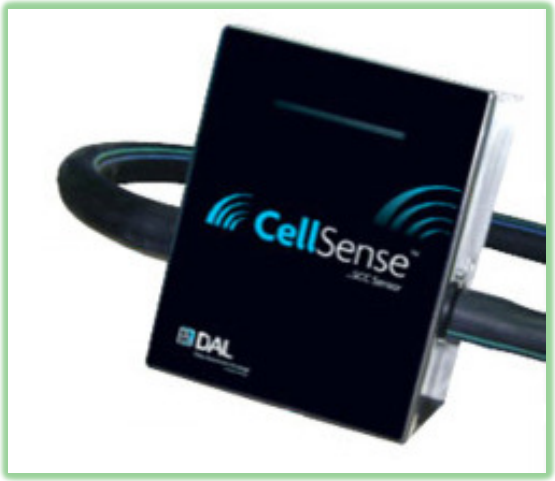
Milk quality measures are affected by sampling time, temperature, milk viscosity, calibration



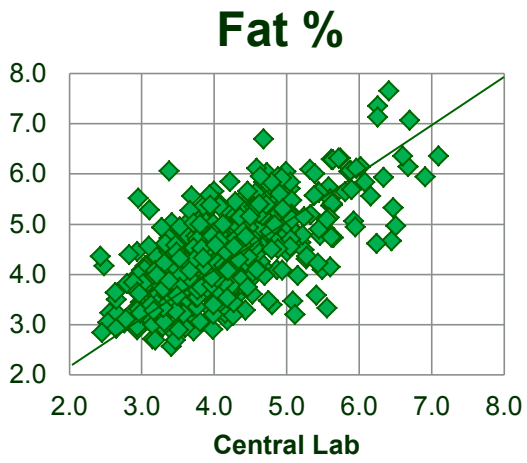
All SCC Values Are Not Equal

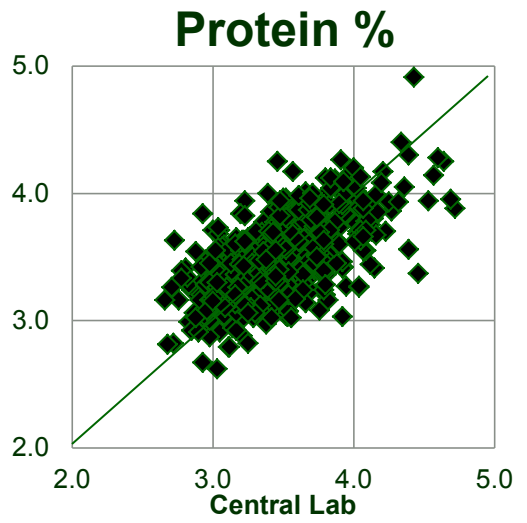
The Case of the CellSense Sensor

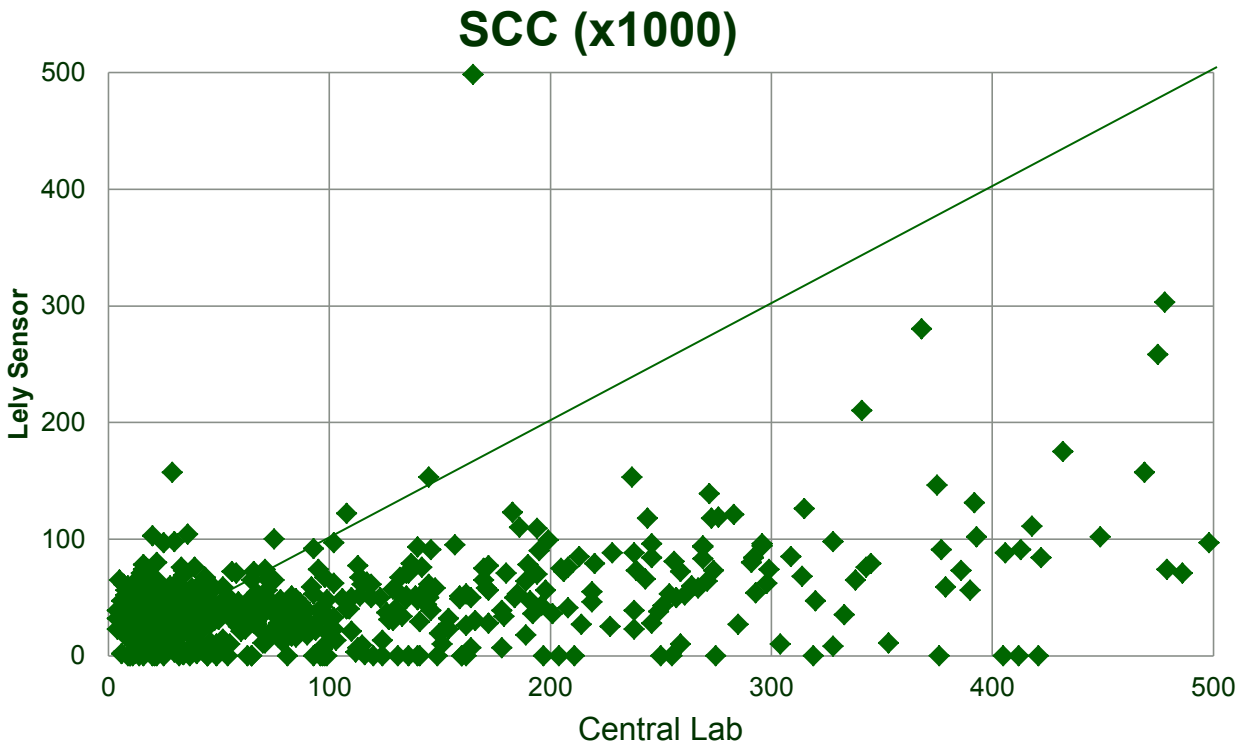
- Automated CMT Test
- Estimates SCC content at 45 seconds into milking
- While correlated to total milk SCC it is NOT the same
- Visual scale of probable SCC value
- Algorithm is based on calibration/adjustment based on DHI SCC values and/or adjustment to bulk tank SCC
- Each sensor has its own bias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



Comparing Lely Sensors vs. Central Lab Component Results







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

Data from RYK (Denmark)

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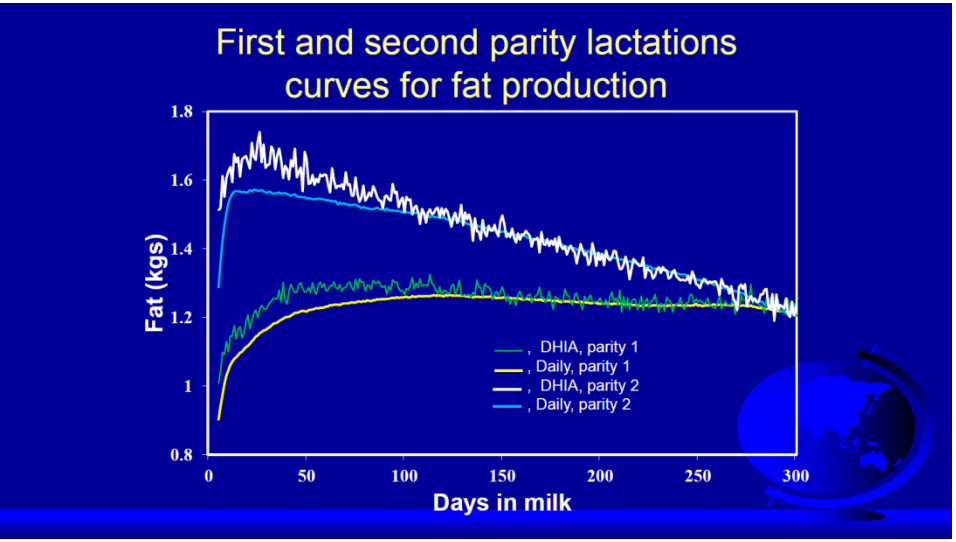
Using SCC Sensors

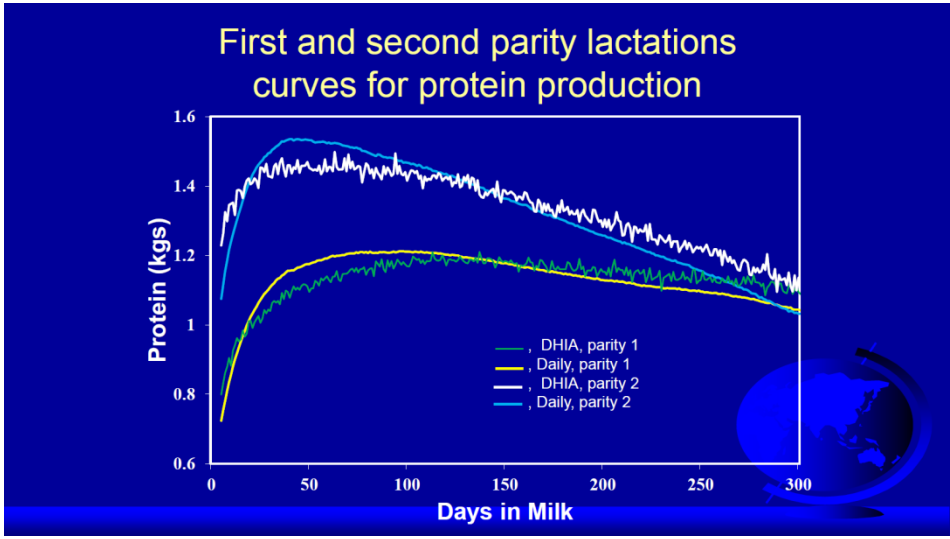
SCC sensors are intended for mastitis management – not animal evaluations

- Alarm or trigger data
- 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 systems 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 Across Yield Volume or Breed

- 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
- Decisions are made at specific DIM or by alarms, not by lactation totals

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Milking Speed Data – Available But Challenging

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	74	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

- Milk flow rates and milking speed data exists in on-farm software
- Different definitions of milking speed (kg/minute, yield over 300 seconds, etc.)
- Millions of observations available
- Data used for on-farm management - cow grouping, parlour efficiency, system performance, milker (human) performance
- Data for genetic evaluations - may be a superior data set to current qualitative coding of milking speed (1-5 scale)

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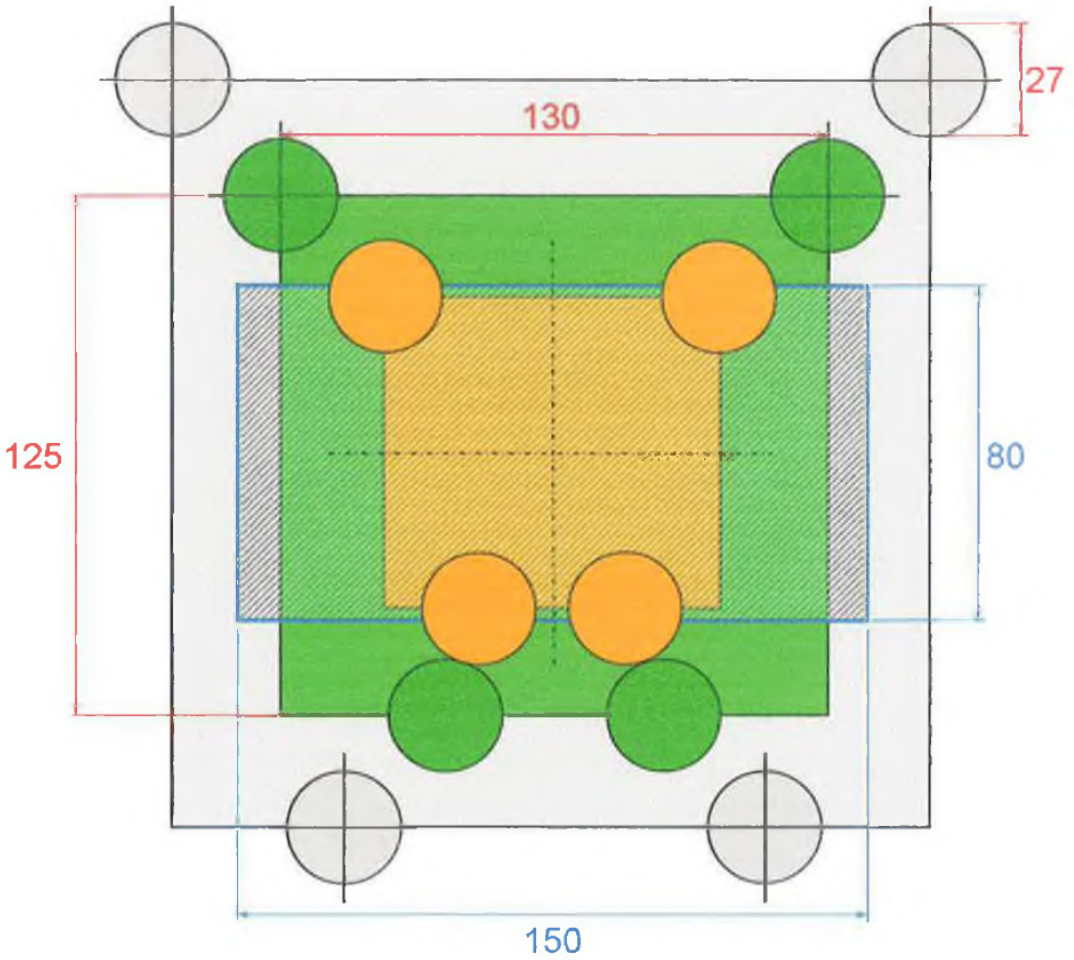
Teat Placement Sensors



- Actual teat location
- Different algorithms and IP by manufacturer
- May or may not have teat shape, length or angle in data set
- Multiple measures over single lactation and over lifetime of cow
- Can we use this data?

We Need to Define the Parameter

Data Definition

- **Define the parameter and recording period**
  - 30 consecutive milkings - SCC
  - fraction of the milking - MS
- **Other data to be captured**
  - animal ID
  - date/time stamp
  - Parlour/stall location where applicable

Data Precision

- **Precision of recording**
  - 4.2% vs. 4.22% vs. 4.222%
  - There is an illusion of increased accuracy in some systems
- **Capture & Averaging**
  - Capture individual data points or mean values?
- **Report SD/SE or Confidence Intervals?**

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Data Validation Questions

Data Handling

- **Handling of missing data points**
  - Estimated data included?
  - Mean of actual data only?
- **Decision rules for handling and/or exclusion of outliers**
- **Data smoothing – monthly or weekly means vs. daily values**

Data Validation

- **Range of accurate measurement for sensor**
- **Distribution of errors**
- **Evaluation of algorithm**
  - May need test data set to send through system algorithm to validate output.

Cumulative Effect of Sensor Errors

AMS/Robotic Systems

- Limited or no choice of milking stall
- Error effect is high

Parallel or Herringbone Parlours

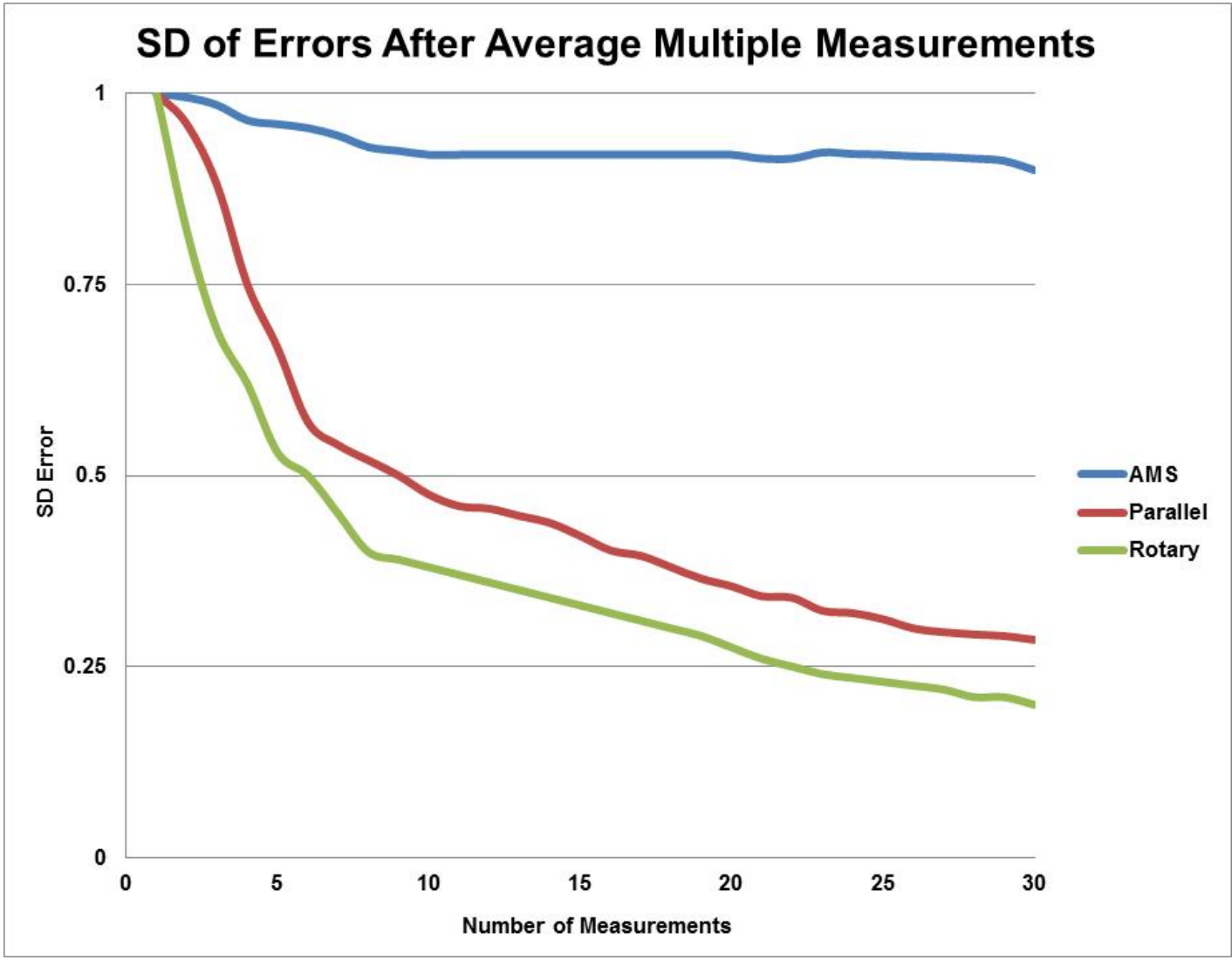
- Cow behaviours lead to trends
- Error effect exists but is moderately low

Rotary Parlours

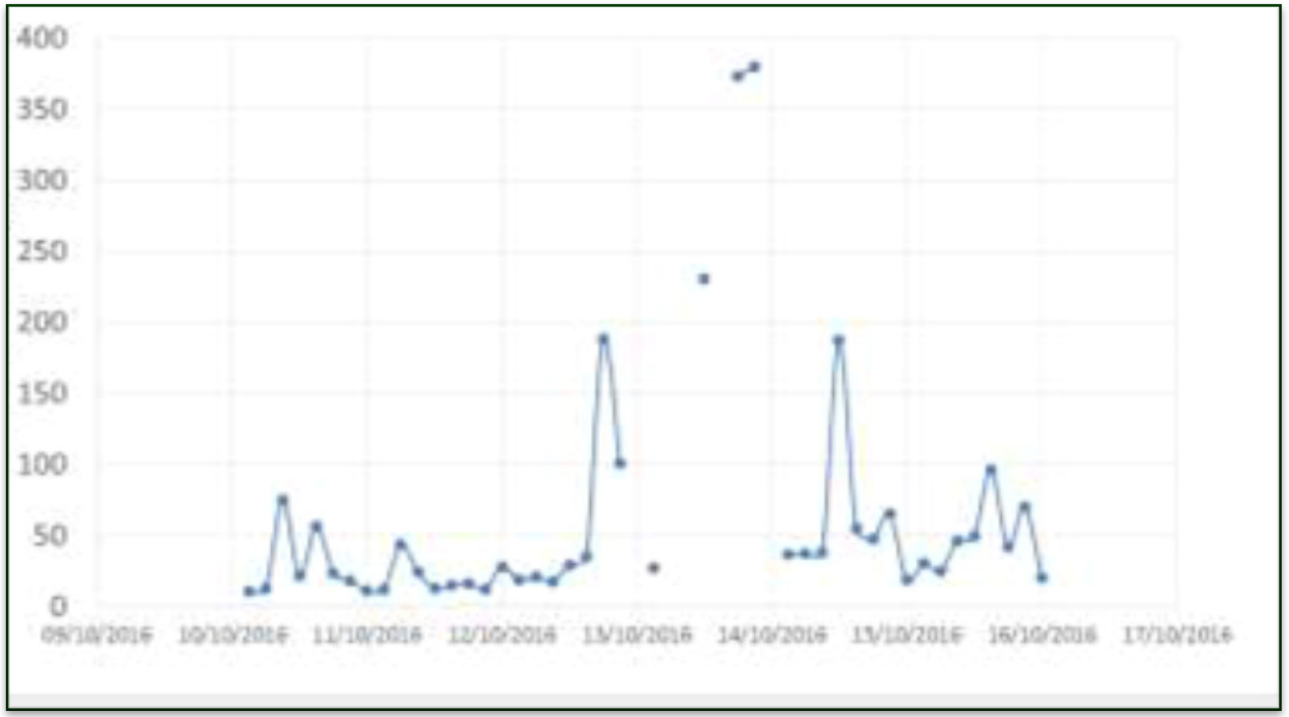
- Random stalls at each milking
- Error effect is low

Cumulative Effect of Sensor Errors

More observations are not the answer in all milk parlour configurations



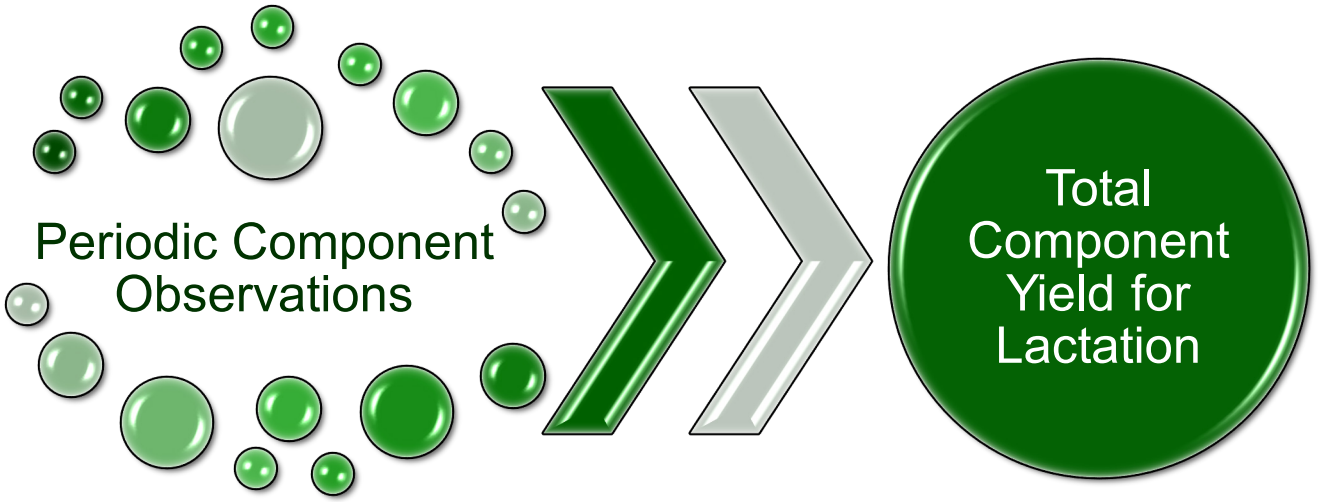
Connectivity is a Concern



Gaps in data observations

- How is the value computed?
- Estimations?
- Mean values without missing data?
- Affects the quality of data entering the system or the management decision process

Managing 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**

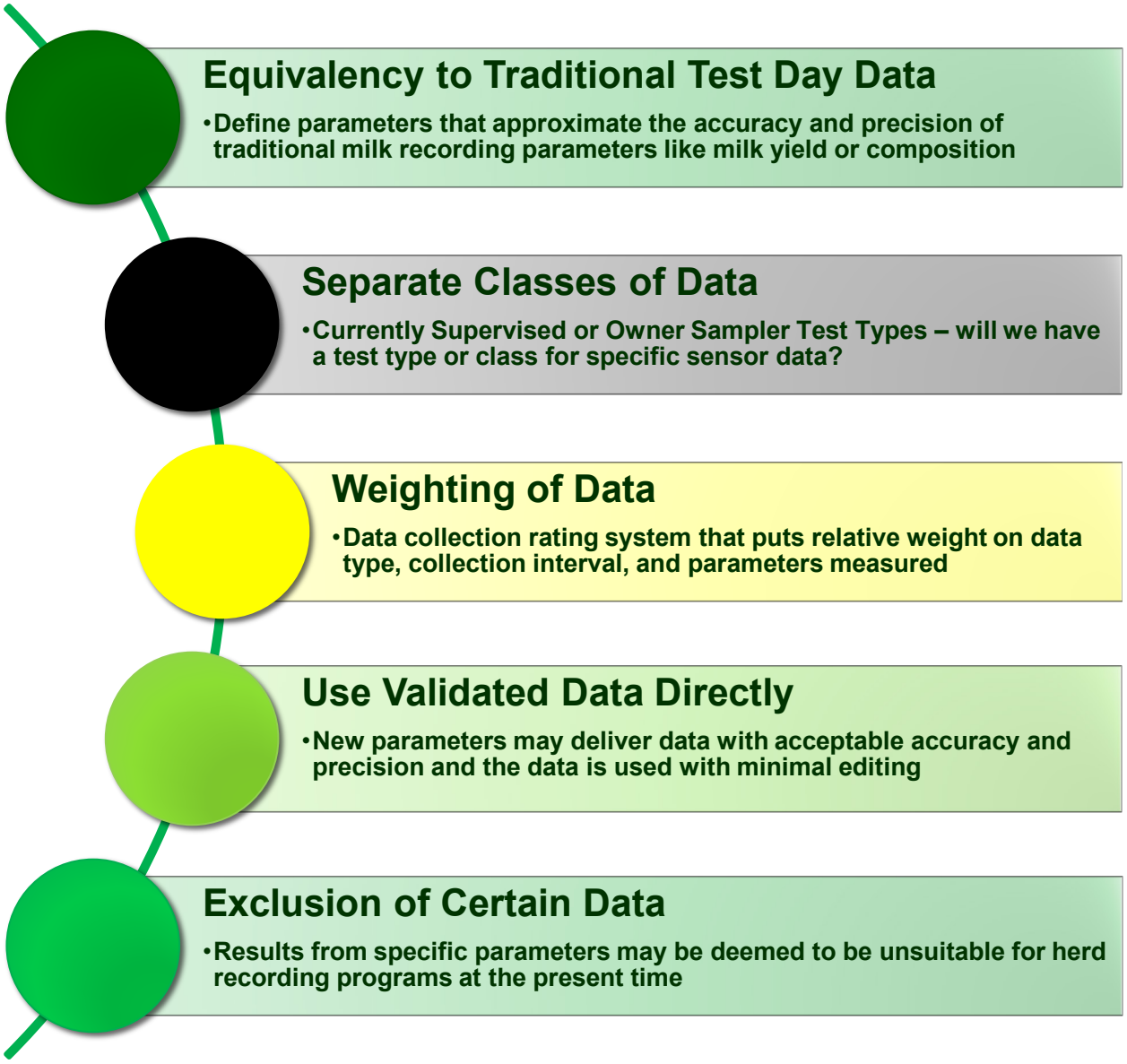
How will we value each data point?

How will we value the whole record?

What information will we deliver?

How Will We Value Sensor Data?

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



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