HOW TO USE PRECISION IN DAY-TO-DAY MANAGEMENT

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This conference focuses on precision dairy management, defined as the use of automation for information collection and process management to improve productivity and profitability. However, information is not collected per se, but in the form of data that then needs to be transformed into information. There are many data options to be collected on a farm: calving dates, insemination dates, whether the breeding was successful or not, dry-off dates, etc. Then, certain calculations and data combinations give us the information we need to evaluate certain areas of the farm, as in this case, reproduction. The main issue becomes in establishing what data we need to collect on each farm that will give us the required information to best manage it within the confines economic viability.

There are many areas on the dairy farm that need to be evaluated for optimal performance, but today we will concentrate specifically on reproductive management and sick cow detection and monitoring.

REPRODUCTION

The eternal question for reproduction in dairy cattle is 'what breeding protocol do I need to follow to get cows pregnant?' However, this is not the real question, because, what do we get by getting every single cow pregnant if later every single one of them aborts? Will be happy if we get them all pregnant after 200 DIM? So, in keeping with the focus of this conference, let's make this question more precise: '**what breeding protocol do I need to follow to get all cows pregnant in time so they calve again within 12-14 months?**' To figure out this protocol, there are two different things that need to happen in series:

1. Cows needs to conceive
2. Cows need to stay pregnant

This means that we need to monitor two separate metrics to evaluate these two separate events. First we need to know how many cows of those we inseminate do conceive. This metric is called conception risk (CR) and is calculated dividing the total number of cows diagnosed pregnant at fist preg check by the total number of cows inseminated. Most people are used to hear the term conception rate, which only applies when it is calculated for a specific timeframe, such as for example a 21-day period.

$$Conception\ risk\ (CR) = \frac{number\ of\ cows\ that\ conceived}{number\ of\ cows\ inseminated}$$

The second thing we need to know is how many cows abort. This metric is called the **abortion risk**, and it is calculated by dividing the total number of abortions by the sum of the total number of pregnant cows and the cows that aborted.

$$Abortion\ risk\ = \frac{number\ of\ cows\ that\ aborted}{number\ of\ pregnant\ cows + number\ of\ cows\ that\ aborted}$$

The rationale behind this is that, epidemiologically speaking, a risk is calculated as animals with a specific event in the numerator, divided by animals eligible to see that event in the denominator. The cows that have aborted were eligible to abort only because they were pregnant, so they need to be included in the denominator. For comparison, think for example of the following metric: if we say 15% of the people attending this conference drove to the meeting (as opposed to 85% flew in), the calculation takes into account in the numerator only those that drove, but in the denominator are all of the attendees to the conference, those that drove and those that flew in.

To complicate matters further, we know that some cows do indeed conceive, but they lose the embryo before preg check. These cows fall into a grey category called early embryonic death (EED), also called embryonic absorption. These are commonly evaluated by assuming that normal heat cycles have 18-25 days intervals, and that anything beyond 25 days is early embryonic death. This then begs the use of another metric to evaluate these cows, and that is the **proportion of insemination intervals that are greater than 25 days**. It is very important to stress that this is an assumption, and that not all cows that have insemination intervals greater than 25 days have indeed absorbed the pregnancy, but they could have had bad heat detection as seen in Figure 1. The counter part of this situation is in situations where cows are bred without being in heat but within a normal interval. This will make the metric look OK, effectively hiding the real problem on the farm (Figure 2).

Although EED and abortions can be due to infectious diseases such as BVD, IBR and leptospirosis, a weak embryo can die early without any other external factors influencing it. Part of the viability of the embryo is derived from an on-time conception with a mature oocyte and vigorous well-capacitated sperm. Other factors include genetic abnormalities and environmental conditions affecting the utero (e.g. fever and prostaglandin release due to inflammation in the cow). Therefore, correct insemination timing is important in making sure that conception happens, but also to make sure that the embryo has the best conditions to survive long-term. But **how do we determine when is the best time to breed a cow?** To answer this question we need information about reproductive physiology, specifically, the duration of certain intervals that have been evaluated with research and are presented in Table 1. Using these ranges, it becomes obvious that the largest variability is in the duration of the actual heat, which is likely the determinant for fertility, and yet it is not something that most heat detection systems are measuring.

- If we only know that the cow ‘is in heat’ (i.e. rubbed off or standing), we need to guess at which point of the heat she is. Timing to ovulation could be anywhere between 10-30 hours; obviously a very large range to determine when to breed.

- If we know when the cow started to become in heat (i.e. increased activity), we need to guess how long she is going to be in heat. Timing to ovulation could be anywhere between 24-42 hours. A narrower range to determine when to breed, but with too much lag time (although this may help farmers that can only breed once a day).

- If we know when she stopped being in heat, we need to guess how long it will be until ovulation. Narrow range of breeding time and short lag time, which doesn’t leave much time for decision making, but provides the best breeding time.

Therefore, if we have a method to determine how long a cow is in heat, we can optimize insemination time. With the advancement of activity monitors over the past recent years, it has become possible to collect data on cow activity every hour of the day, so that decisions can be made almost immediately. For example, with the new AfiAct II system from Afimilk Ltd. it is possible to, not only determine when a cow starts coming in heat (increase in activity to over twice the baseline), but it is also possible to determine when the peak of that activity happens, as well as when it ends (Figure 4). This leads to much more precise decisions on when the best time to breed a cow is. To fine-tune the best insemination time for each cow the farm can use automatic sorting gates that will place the cows in an accessible area without having to disturb the entire pen. Another viable option is to determine what the pattern of the majority of the cows is, and then adequate insemination times to the average cow in that farm. Collecting data on each cow on the farm will produce enough information to be able to customize the day-to-day management based on results on that specific farm, as opposed to basing decisions on research performed in different farms and under different conditions.

Table 1. Critical timings for fertilization in cattle

Event	Avg time (hrs)	Range (hrs)
Pro-estrus duration (start of activity)	6	
Estrus duration (standing heat)	12	6 - 24
Estrus to ovulation	28	24 - 42
Oocyte life span		10 - 12
Oocyte migration to fertilization site	6	
Sperm life span		8 – 24

Sources:
Senger PL. Pathways to pregnancy and parturition. 1999. Current Conceptions, Inc. Pullman, WA. 1st Rev Ed. 281 pages.
Saumande J and Humblot P. The variability in the interval between estrus and ovulation in cattle and its determinants. Anim Reprod Sci. 2005 Feb;85(3-4):171-82.
Hawk HW. Sperm survival and transport in the female reproductive tract. J Dairy Sci. 1983 Dec;66(12):2645-60.

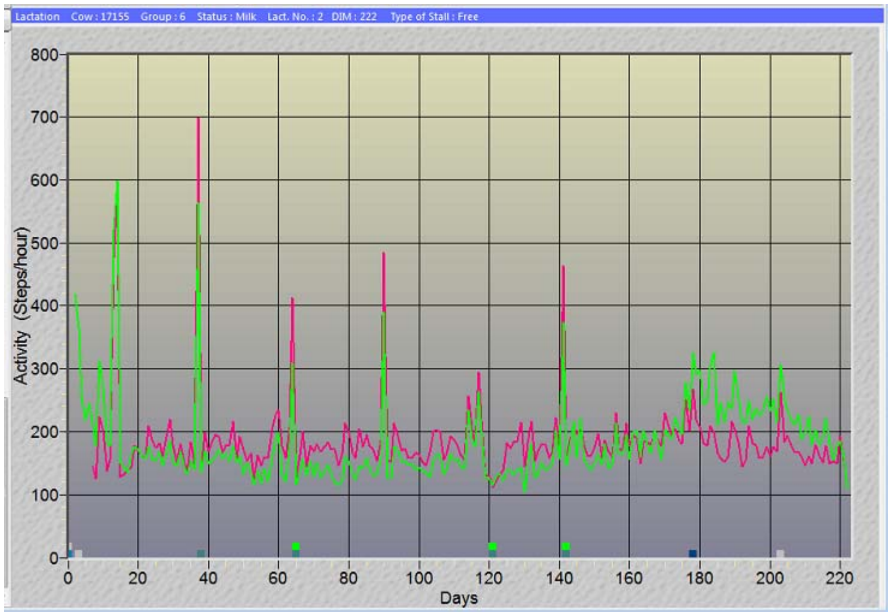

Figure 1. Cow inseminated 56 days after previous insemination that had a normal heat 25 days after previous insemination. Notice the heats indicated by high activity in the graph at 14, 37, 65, 90, 119 and 141 DIM. Inseminations are indicated by lime green boxes next to the X axis, at 65, 130, 121 and 141 DIM. The rugged activity past 180 DIM likely indicates lameness. Notice that she was in heat at 90 DIM but was not bred. Therefore, she will count in the metric as a long interval between breedings, which will be assumed an EED, when in fact she was in heat but was not bred (breeders in this farm were not following instructions correctly). This cow conceived to the breeding at 141 DIM, as indicated by the blue box next to the X axis at 178 DIM 9day of preg check). Source: AfiFarm software, Afimilk Ltd.

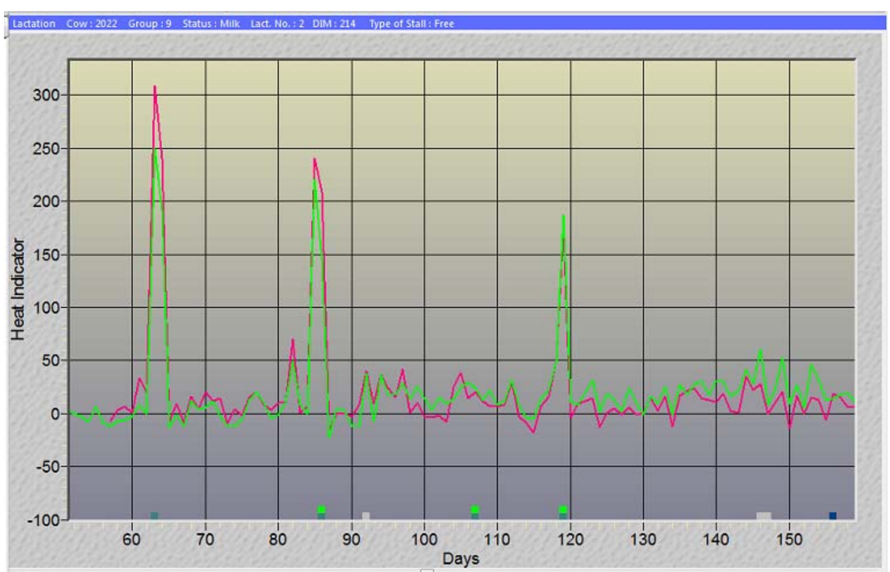

Figure 2. Cow that has been in heat 3 times and has been bred 3 times, but not at the appropriate times. Heats are indicated by high activity days at 63, 86 and 119 DIM. However, she was not bred at 63 DIM (before VWP). Instead she was

bred at 86, 107 and 119 DIM, indicated by the lime green boxes (the breeders on this farm were still detecting heats visually and estimated that this cow was rubbed off). This cow will count as a normal breeding interval of 21 days (107-86) and a short breeding interval of 12 days (119-107), when in fact her real interval as determined by the high activity measured by the pedometers is 33 days (119-86), indicating a problems of early embryonic death (EED) that will be hidden from the evaluation if only numbers are being evaluated. This cow conceived to that last insemination, as indicated by the blue box at 156 DIM. Source: AfiFarm software, Afimilk Ltd.

Farm A

	Heifers (pre)	Heifers (pre) %	1st lact.	1st lact. %	2nd lact	2nd lact. %	3+ lact.	3+ lact. %	All cows	All cows %	Total	Total %
Distribution of cycles: 5-17 days	6	5.56	16	12.90	4	7.69	3	3.41	23	8.71	29	7.80
18-25 days	93	86.11	76	61.29	35	67.31	51	57.95	162	61.36	255	68.55
26-35 days	3	2.78	14	11.29	5	9.62	14	15.91	33	12.50	36	9.68
36-60 days	6	5.56	18	14.52	8	15.38	20	22.73	46	17.42	52	13.98
Average days between Breedings	22		24		25		28		25		24	

Farm B

	Heifers (pre)	Heifers (pre) %	1st lact.	1st lact. %	2+ lact.	2+ lact. %	All cows	All cows %	Total	Total %
Distribution of cycles: 5-17 days	--	--	10	5.56	46	6.07	56	5.97	56	5.97
18-25 days	--	--	91	50.56	357	47.10	448	47.76	448	47.76
26-35 days	--	--	43	23.89	188	24.80	231	24.63	231	24.63
36-60 days	--	--	36	20.00	167	22.03	203	21.64	203	21.64
Average days between Breedings	--		28		28		28		28	

Figure 3. Comparison of interval between breedings in two farms. Farm A has a normal profile (5-17 days <10%, 18-25 days >60%, 26-35 days <15% and 36-60 days <15%), Farm B has a problem with early embryonic death (EED) evidenced by the large proportion of cows with long intervals between breedings (target in our farms is <15%). Source: AfiFarm software, Afimilk Ltd.

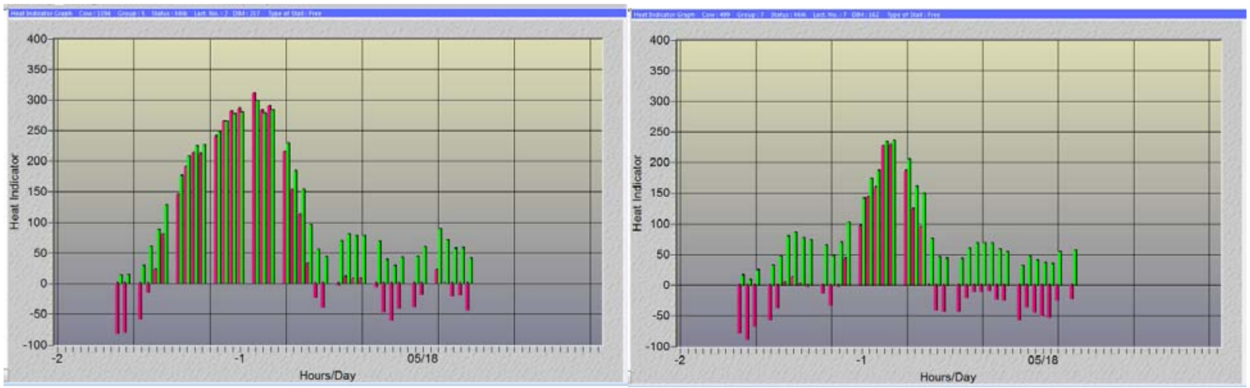

Figure 4. Hourly graphs of activity. The cow on the left was in heat for 16 hours, while the cow on the right was in heat only for 6 hours. Both belong to the same farm. Source: AfiAct II software, Afimilk. Ltd.

SICK COW DETECTION

As any living being, cows will encounter health issues along the way, and therefore, we must maintain vigilant every day to detect which cows may be having issues, so they can be treated promptly and effectively to ensure prompt recovery. Then we need to monitor them until they recover, so we can make sure that our treatment protocols are appropriate and, if not, we have the ability to make an informed decision to change those protocols.

When evaluating sick cows, typically most farmers look at milk production. Although it is a good indicator, it is not very specific, so we can see milk drops in cows that have changed pens or cows that are in heat. This means that, in addition to milk information, we now need event information and activity (for heat detection). Compare for example the cow in Figure 5 and Figure 6; both have dropped milk by more than 30% in the last 1-2 milkings. The difference is that the cow in Figure 5 is in heat, so that the drop in milk can be explained by the increased activity and lack of resting /eating times, while the cow in Figure 6 has mastitis, as evidenced by the increased conductivity. Figure 7 shows a cow that has dropped in milk, but is not in heat and does not have mastitis; she is off-feed, which can be due to a digestive issue or pneumonia (can't eat well because she can't breathe well). Finally, Figure 8 shows a cow that is lame, as evidenced by the ragged activity graph. Therefore, with a milk meter that provided information on milk production and conductivity, and a pedometer that measures activity, we can now detect not only that a cow is sick in general, but actually hone into what the likely diagnosis is. The addition of other sensors that can measure milk components such as butterfat, protein and lactose, can help fine-tune the diagnosis even further.

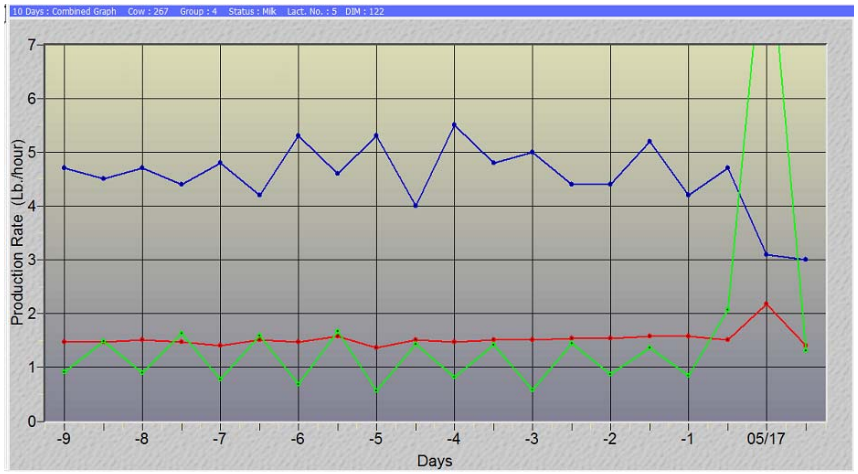

Figure 5. Graph showing milk production (blue) at each milking (2x) and activity (green) for a cow that has dropped in milk production because she is in heat. Conductivity (red) shows a small rise typical of cows that retain their milk (heat). Source: AfiFarm software, Afimilk, Ltd.

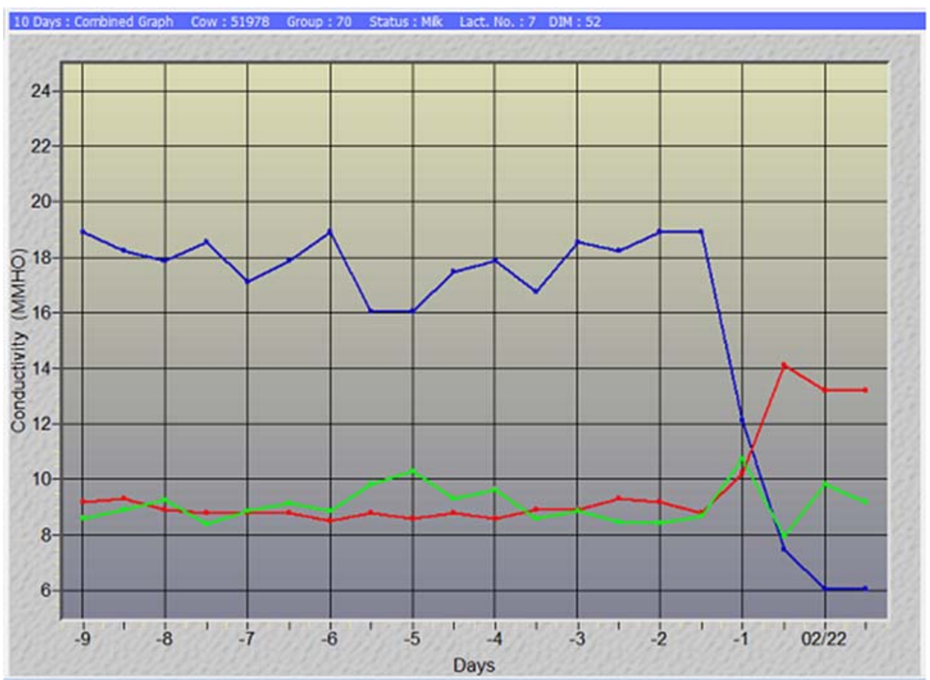

Figure 6. Graph showing milk production (blue), activity (green) and conductivity (red) at each milking (2x) for a cow that has dropped in milk production because she has mastitis. Conductivity shows a sharp rise and activity is flat or slightly decreased. Source: AfiFarm software, Afimilk, Ltd.

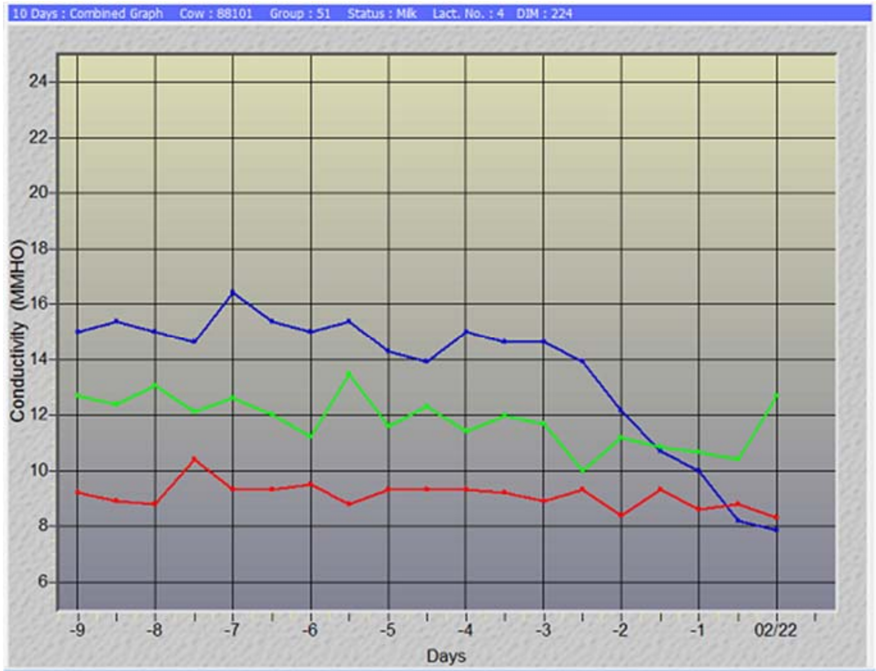

Figure 7. Graph showing milk production (blue), activity (green) and conductivity (red) at each milking (2x) for a cow that has been gradually dropping in milk production due to being off-feed (digestive issue or pneumonia). Conductivity and activity are relatively flat, while milk production dropped over a span of at least 3 days. Source: AfiFarm software, Afimilk, Ltd.

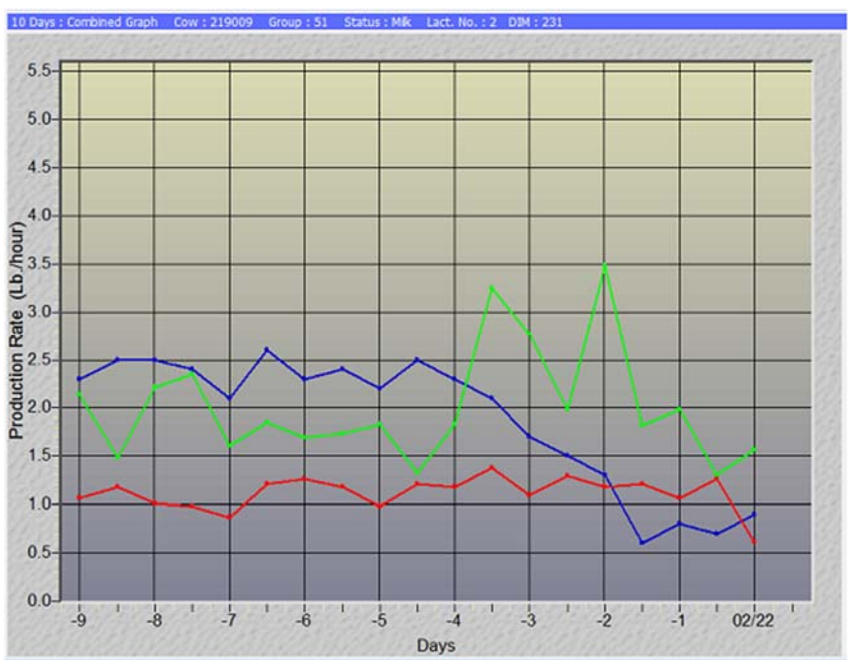

Figure 8. Graph showing milk production (blue), activity (green) and conductivity (red) at each milking (2x) for a cow that has dropped milk production because she is lame. Activity shows a ragged increase as opposed to a flat line or quick up and down (heat) as in the other graphs. Source: AfiFarm software, Afimilk, Ltd.

In conclusion, the use of automatic data collection tools and the evaluation of specific combinations of the data provided by these tools can give us the necessary information to manage a farm on a day-to-day basis. Having more sensors and more data, however, is not useful if the data provided by these technologies is not integrated to provide information on which one can base decisions such as when to breed a cow to optimize pregnancy to term, or how to optimize the ability to provide an accurate diagnosis for a sick cow within 1 or 2 milkings so the cow can be adequately treated and promptly recover.

There are many options of technology available to dairy farmers nowadays, anywhere from automatic calf feeders to automatic in-line milk components sensors. To determine what fits within a farm, all technology needs to be evaluated trying to answer the question of '**what information will we get from the data provided by this tool and how will we change the management in response to that information?**' That is what provides precision in day-to-day management.