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Executive Summary

This Industry Innovations Report is a snapshot of sensor technology known to be available as at 31st August 2016. The purpose is to collate this information into a single document, which will then form the basis for a Warehouse of Technologies

It is a living document and will be added to in line with information provided by the Community of Practice. The updated document and the Community of Practice can be accessed at www.4D4F.eu .

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I. General aspects regarding the use of sensors in dairy farms

The use of sensors and technologies based on sensors are becoming increasingly widespread, both in agriculture in general and in animal husbandry in particular. The sensor-based technologies in dairy farms provide real-time information from which management decision can be made. Sensor technologies are being used to monitor the production and physiological condition of the animals, thereby contributing to animal welfare, animal health and food safety.

Sensors and sensor-based technologies in dairy farms, as part of precision integrated management, are being used for various reasons. Some examples include:

- Identifying each animal using electronic identification (EID).
- Detecting the oestrus and the health status of the animals.
- Recording the activity and position of the animals.
- Monitoring the rumination activity and feeding patterns.
- Robotic milking.
- Automatic mastitis detection.
- Body condition scoring

Farm management is assisted by sensor systems collecting information about milk production, reproduction and animal health status. Increasingly, these innovations are leading to a more efficient performance of dairy cows, in terms of both physiology and profitability. This report[1] will give an overview of the commercial sensor-based devices that are currently available in Europe.

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[1] *Please note that the current list is not exhaustive, and that the description of the technologies is based on (verbatim) information provided by the technology producers.*

II. Sensors for monitoring the reproduction activity

1. Estrus detection

Heat detection in high performance dairy cows becomes increasingly difficult for several reasons: a short manifestation of estrus, lower intensity of the specific heat-associated behaviour, the increasing size of the farms, etc. Fortunately, estrus can be monitored continuously (day and night) thanks to automatic heat detection systems. Automatic heat detection systems are available in the form of leg tags, neck collars or ear sensors. The following examples of commercial devices will be listed by company. While some heat detection sensors can also be used to monitor rumination, these are not listed separately in the paragraph below, but are listed in the section on rumination sensors, in chapter V.

1.1. Afimilk (http://www.afimilk.com)

AfiAct II Leg Tag / AfiTag

AfiAct II supports herds of any size. Able to integrate with AfiMilk's farm and milking parlour management system, AfiAct II is accessible from the web on any type of device such as a smartphone, tablet or laptop. It is works with an off-the-shelf Wi-Fi router and requires no network cabling. AfiAct II is available as a standalone system. AfiTag (Pedometer and Pedometer Plus) is a dual-purpose electronic device that reliably and accurately performs animal ID and gauges behaviour patterns.

AfiTag II   *Pedometer and Pedometer Plus*

Summary of AfiAct II:

- Collects and updates activity and behavior data all the time;
- Indicates decrease in activity (lame or sick cows);
- Provides early detection of anestrus, abortion and cyclic disorders;
- Records history of heat patterns throughout cow's entire life;
- Provides fertility indexes, conception rate per bull and per inseminator.

1.2. GEA (http://www.GEA.com)

CowScout I / S

The CowScout sensor from GEA is available both as a neck collar and leg tag. Whether the sensor is on her neck or leg, it monitors the animal's movements at all times and reports the reports measured activity to the processing unit via antennas at frequent, regular intervals. The unit then analyses all of the data and shows periods of high activity for each individual animal. CowScout displays time spent lying, standing and walking. The neck collar can also monitor the cows' eating times.

CowScout I includes an animal recognition function (ISO-identification) for connecting to a herd management system, while CowScout S is meant for operations without a herd management system or where electronic animal recognition systems are already in place.

The CowScout was originally developed by Nedap, and is currently also being marketed as Heatseeker II by Boumatic (see below).

Rescounter III

Rescounter III is available as a leg or neck-mounted version. It displays the activity every two hours so that signs of heat can be reliably recognised. The new Rescounter III (leg and neck) can be used as a replacement part within and for the extension of existing systems together with the predecessor, Rescounter II.

1.3. IceRobotics (http://www.icerobotics.com)

IceQube / IceTags

IceRobotics offers two kinds of sensors: one for commercial dairy farms (i.e. IceQube) and one for research institutes (i.e. IceTag). IceQube has a 9-day memory and the data is summarized into 15-minute blocks, whereas the IceTag has a memory of 60 days, and their data can be viewed and manipulated down to individual seconds. The data of both sensors can be downloaded manually via desktop reader, or automatically –in case of the IcQube- via the wireless infrastructure on farm.

IceQube   IceTag

1.4. Select Sires (*http://www.selectsires.com/*)

Select Detect

Select Detect measures cow activity using MEMS (Micro Electro-Mechanical Systems) based sensing and stores information internally. Periodically, the recorded data is transmitted wirelessly to the base station in a radios of 90 metres. The software running on the farm's computer then downloads the activity data from the base station for analysis. The manager still needs to confirm the heat and enters either « heat » or « breeding » into the program.

SelectDetect was originally developed by DairyMaster, and is also being marketed as MooMonitor.

1.5. DeLaval (*http://www.DeLaval.com*)

DeLaval Activity Meter System

The DeLaval activity monitoring system is a part of the DeLaval ALPro herd management software. The system records activity on an individual cow basis. This activity monitor is mounted on a collar.

DeLaval Activity Meter

DeLaval Herd Navigator

The Herd Navigator has the capabilities to measure progesterone levels during robotic milking (i.e. in-line). The analyser instrument can be installed in combination with the automatic milking system of DeLaval (up to 8 VMS stations), or with conventional milking systems (herringbone and parallel parlours). The biological models in Herd Navigator determine automatically from which cows a milk sample will be taken, at which milking; and which milk parameters to analyse. It measures the following parameters in milk:

- Lactate dehydrogenase (LDH) for mastitis;
- Progesterone for heat detection and pregnancy checks;
- Beta-hydroxybutyrate (BHB) for ketosis;
- Urea for feed-protein balance

1.6. Boumatic (http://www.boumatic.com)

Heatseeker II

HeatSeeker II monitors and records a cow's activity and helps identify the moment a cow shows signs of increasing activity and could be ready for reproduction. More efficient reproduction means lower costs and higher profits for your operation. The system includes a controller, ankle or neck tags, floor-mounted or walk-through antennas and a power supply.

The Heatseeker II was originally developed by Nedap, and is currently also being marketed as CowScout by GEA (see above).

HeatSeeker II Leg Tag

HeatSeeker II Neck Tag

1.7. Lely (http://www.lely.com)

QWES H / HR

Lely offers different models of activity meters with or without rumination monitoring (QWES-HR vs. QWES-H). The QWES-H is a collar-mounted cow identification and activity sensor. A sophisticated acceleration sensor measures activity levels (duration and intensity of movements). The additional functionality of the QWES-HR system is that it also measures the cow's ruminating activity. The cow's activity is monitored in 2 hours' time blocks, which provides a highly accurate control of individual cow behaviour. The tag quantifies all cow movements such as walking, laying, standing up, head movements and creates a general activity index. Together with the T4C management software, this information allows differentiation between increased activity associated with oestrus and other activities such as walking to the pasture or any other occasional activities. The tag stores data from the last 24 hours.

Some cows show a temporary increase in activity, but are not in heat. By calculation of the heat probability, the number of false positive cows on the attention list is reduced.

Cow with QWES collar.

QWES is based on technology designed by the Israeli company SCR, which is also included in the heat detection systems of Semex.

1.8. Nedap

Smarttag Neck

Nedap offers the Smarttag Neck for heat detection combined with monitoring of eating behaviour. The system provides high-precision, automatic heat detection at distances of up to 500 metres around the antenna. It records the time each day an

animal takes in roughage or grazes. Changes in this eating behaviour can reveal that there may be something wrong with the animal and that it needs further attention.

Nedap Smarttag (neck collar)

The technology designed by Nedap is also integrated into the heat detection systems of Boumatic and GEA (see above).

2. Predicting the moment of calving

An accurate and timely prediction of calving time can be of great help for a dairy farmer. Most of the time, farmers decide when to move a pregnant cow to the maternity pen, or assist during the calving, based on visual symptoms. Yet, there are various on-farm devices being marketed for calving detection. They are usually based on (1) registering vaginal temperatures, (2) measuring abdominal contractions, (3) tail movements, (4) cow behaviour or (5) the actual expulsion of the calf.

2.1. Afimilk (http://www.afimilk.com)

AfiAct II
AfiAct II's calving alert service is using 24/7 cow behavior monitoring analyzed by advanced algorithms implemented in the AfiFarm management software. As a result, it provides alerts with high accuracy (typically, the actual calving takes place within 4 hours from the received alert). Although in some cases a calving event can be missed, a false alarm is extremely rare (under 10%). The timeline for the system's alerts is as follows:

    1. First alerts – Alerts the farmer to when calving is about to start. He or she can then prepare by moving the expecting cow to the calving area. High risk calving, such as twins or cows that are inducted, is noted in order to arrange for special care.

2. <u>Second alerts</u> – Alerts the farmer to prolonged calving and the risk of dystocia to determine whether intervention is needed. Preparing early for intervention may save both the calf and the cow.

3. <u>After calving</u> – The newborn calf must now be moved to a safe environment and fed with colostrum milk. The cow must be taken care of as well.

2.2. Moocall (http://www.moocall.com)

Moocall is a non-invasive, tail-mounted sensor that gathers over 600 pieces of data a second. It predicts when the cow is most likely to give birth by measuring tail movement patterns triggered by labour contractions. When they reach a certain level of intensity over a period of time it then sends an SMS text alert directly to your cell phone on average 1 hour prior to calving.

Moocall sensor

2.3. Medria (https://www.medria.fr/en_GB/produits/vel-phone.html)

<u>Velphone</u>

The Velphone sensor is a vaginal thermometer fitted with different inserts depending on the cow breed or age. It measures and records the temperature and sends the data to the Medria box. Based on the cow's temperature analysis, the Vel'Phone notifies the farmer of imminent calving. The vaginal thermometers are put into place 7

days before the expected calving and inform him (via SMS) of the explusion of the water bag. It can follow also the temperature development day after day and send a SMS text before the expulsion of the water bag, when the temperature starts to drop.

2.4. Cowcall (http://www.cowcall.com)

Small, compact, light and temperature sensitive device is placed in the vagina of the cow up to 14 days prior to calving. The unit is connected to a base station installed in a key location on the farm. When the cow's waters break, the device is pushed out. Once outdoor light is detected, a message is immediately sent to the base station. Here the information is analysed. A SMS & phone call is sent to the farmer to alert him/her that calving has commenced. The device will shut down after 20 seconds of been passed out.

III. Sensors for monitoring the health status

1. Body temperature

1.1. CorTemp

Core body temperature is an important parameter for assessing cattle state-of-health. The CorTemp unit consists of an ingestible bolus and a receiver unit . The bolus houses a temperature sensor, low-power RF transmitter, and power source capable of providing up to nine months of power. The bolus is designed to lodge in the reticulum of the cow and remain there, not passing through the animal's digestive tract. Once the bolus battery is exhausted, a new bolus can be administered to the animal, with no harm to the animal.
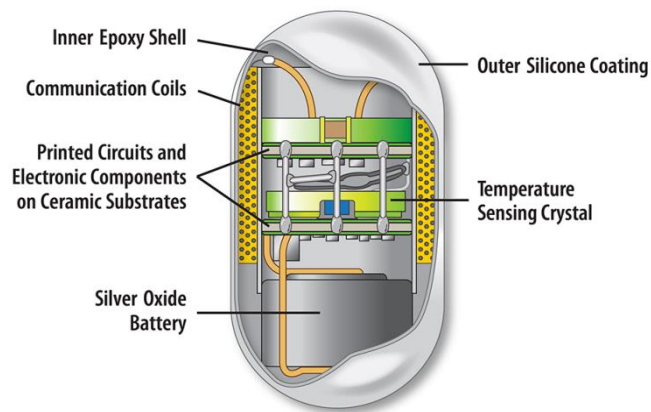
CorTemp

The sensor passes through the body at the subject's normal rate of motility which can vary anywhere from 24-36 hours. Monitoring can be extended by administering another sensor after the initial pill has passed. The CorTemp sensor is accurate to ± 0.1°C.

1.2. Cowmanager (http://www.cowmanager.com)

SensOor

The SensOor is an innovative product developed by Agis Automatisering. It comprises a moulded chip that can be connected to an electronic eartag of a cow for monitoring the (ear) temperature, rumination time, feeding time and activity patterns.

The CowManager system contains 4 modules: Fertility, Health, Nutrition and Find my Cow.

SensOor

1.3 TempVerified Fever Tags http://www.fevertags.com/#!tempverified/cgsi

Inserted into the ear canal, this sensor monitors temperature every 15 minutes, and then alarms (a red flashing light), when the preset timing parameters have been reached.

- Example, breach setting of 39.7˚C and verify the "occurrence" for 6 hours.

- Once an alarm is active, proceed with your established treatment protocol.

- Once the animal has reduced the high temperature episode or responded to treatment the device will revert to monitoring each 15 minutes.

- If the animal did not respond to treatment the device will re-alarm and begin flashing again.

- The eartags can be reused

-

TempVerified fever tag

2. Mastitis

2.1. MilkHub (www.tru-test.com/dairy)

This sensor is mounted onto the main milk line, the long milk hose is connected directly onto the in-line sensor and from there onto the main milk line. A single sensor provides cow mastitis, yield, plant cleaning and milking measurements.

Milkhub

2.2. MastiLine (http://www.mastiline.com)

MastiLine is a new system developed for dairy farmers for the early diagnosis of sub-clinical mastitis through ATP-bioluminescence, which gives an indirect indication of the somatic cell count in the milk.

2.3. Mastitis detection in automatic milking systems (AMS)

There are various sensors for automatically detecting mastitis (see Table 1). All AMS models are equipped with sensors that register electrical conductivity, milk color and milk yield. The different AMS models will further be discussed in detail in chapter IV.

Table 1. Mastitis detection in commercial AMS.

AMS	DeLaval VMS	Lely Astronaut	GEA MIone	Fullwood Merlin	SAC Futureline	Boumatic MR-S1
Electrical conductivity	x	x	x	x	x	x
Milk color	x	x	x	x	x	x
Milk yield	x	x	x	x	x	x
Milk temperature	-	x	-	x	-	-
Cell count	(x)	(x)	-	-	-	-
Lactate dehydrogenase	(x)	-	-	-	-	-

x signifies that the particular sensor is present in the AMS model ; (x) means that the sensor is optional.

2.4. DeLaval

Herd Navigator

The Herd Navigator can be used to monitor mastitis, ketosis, and the reproduction cycle. Please see chapter I.

DCC

The DCC measures the somatic cell count of milk. DCC counts the somatic cells optically. A digital camera inside the instrument takes a picture of the somatic cells' nuclei, which is stained in the cassette with a DNA specific fluorescent reagent. DCC is a portable instrument and does not necessarily require external power.

DeLaval's cell counter (DCC)

3. Body condition scoring

3.1. DeLaval

DeLaval BCS

The BCS camera is mounted on a DeLaval sort gate or on DeLaval VMS. It takes a 3D image of the cows' lower backs every time they pass under the camera. It then calculates the body condition score of each cow and sends it to DeLaval DelPro Farm Manager where the farmer can view graphs of individual animals, groups or the entire herd. DelPro Farm Manager can be set to notify you if a cow falls below a certain score.

The BCS camera of DeLaval.

4. Rumen pH

4.1. SmaXtec (http://www.smaxtec-animalcare.com)

SmaXtec pH & Temp Sensor

The smaXtec pH & Temp Sensor is designed to provide a continuous measurement of ruminal pH and temperature of cows. The recorded data is transmitted wirelessly to the base station in real-time. Shelf life from date of manufacture is limited (up to 18 months) with an accuracy of pH ±0.2 until day 90.

SmaXtec bolus

4.2 eCow (http://www.ecow.co.uk)
eBolus (designed for research), and farmBolus

Both boluses measure pH and temperature with an accuracy of +/- 0.1 pH and +/- 0.1°C or up to 6 months. Small, with a size of 27 by 135 mm long,and weighing 150g they have a shelf life of 2 years. In the farm situation the boluses are often used in sentinel cows to monitor and optimise feeding regimes, or in individuals to diagnose SARA.

eCow eBolus.

5. Rumination

Please see chapter V for more information on sensors for monitoring rumination activity.

IV Automatic milking systems (AMS)

Automatic milking systems (AMS) are becoming increasingly popular. The technology was first marketed in the nineties, but nowadays, over 25.000 dairy farms are equipped with AMS. After the introduction of Lely's Astronaut milking robot, various other manufacturers (such as DeLaval, Boumatic, GEA, and Fullwood) followed. Since the nineties, the manufacturers have made great technological progress in terms of robotic milking.

There are some notable differences between the AMS models of different manufacturers, such as the way teats are cleaned, the position of the robotic arm, the energy efficiency and water use. Other characteristics, such as a systemic wash every 8 hours and the provision of concentrates, are more or less the same for every AMS model. This chapter will give a brief overview of the most popular robotic milking systems.

1. *Boumatic (http://www.boumaticrobotics.com/en/home/)*

The American company Boumatic has developed two kinds of milking robots:

- **MR-S1** milking robot one unit for one cow. In this system, the identification system recognises the cow, determines whether it is time for it to be milked and then decides how much concentrate it should be given. The robot arm then approaches the udder between the cow's back legs. The latest camera techniques enable the teat position to be ascertained and the milk beakers to be connected. The robot completes the entire milking process from the enclosed technical area. From washing and pre-milking with the separate pre-treatment beaker (the teats are individually cleaned and pre-milked) to the actual milking process and post-milking teat procedures. The milking process is continuously monitored via the various sensors and measurement devices. Deviations within the milking process are immediately and clearly flagged up. If necessary, this data can be sent to a smartphone or iPad.

- **MR-D1** is a Milking robot with a double box, made for milking of two cows. The system is set up to milk two cows, standing side by side, simultaneously. The milking robot has a well-organised technical area and one robot arm, in one unit.

2. Fullwood (http://www.Fullwood.com)

The **Fullwood M²erlin** features a unique twin-exit design which enables the milking machine to act as a segregation system, with cows exiting either via a side gate or straight ahead. It is also available in either a side or straight entry configuration. The new Fullwood M²erlin is available in three specifications, from the entry-level M² Essential, to the mid-range M² Extended and advanced M² Expert.

3. DeLaval (www.DeLaval.com)

The AMS model of DeLaval is called **VMS**. The VMS' hydraulic powered robotic arm provides extended reliability and reduces service requirements when compared to pneumatic systems. DeLaval VMS hydraulic arm is fast, quiet, robust and gentle. Each teat is individually cleaned with warm water and air, then stimulated, pre-milked and dried before milking. The teat preparation cup has its own separate line so no dirty pre-milk ever makes contact with the main milk line. The VMS Supra is equipped with an additional online cell counter, whereas VMS Supra+ is combined with the Herd Navigator.

4. GEA (www.GEA.com)

The **Mlone** multibox system can be configured with 2 to 5 boxes. and is recommended for herds of up to 120 cows. All tasks can be controlled and monitored quickly and easily from one central management station. While low-maintenance cows are being milked automatically, animals that require special attention can easily be tended to through simple, convenient functions.

5. Lely (www.lely.com)

The **Astronaut A4** Milking Robot is part of an automated milking system that milks, feeds, and monitors the health of cows. The milking system also examines the quantity and quality of the milk received from the cows, and if necessary, it separates milk that is contaminated or is not to the correct standard. The milking system has four primary parts: the milking robot (one or more), the milk storage tank, the control system and the compressor. The milking robot has two primary parts: a central unit that supplies power, water, cleaning solutions, regulates pressurized air and applies a vacuum, and one or two robot units where the cows are milked.

Boumatic MR-S1

Boumatic MR-R1

DeLaval VMS

Lely Astronaut A4


GEA Mlone multibox system

Fulwood M²erlin

5 Sensors used for monitoring feeding

1. Robotic calf feeders

Automatic calf feeding systems reduce labor and reallocate it to monitor and manage calf health and performance using a variable schedule. Well organized group housed calf rearing systems offer advantages for calves and producers.

Automatic calf feeders contain a self-contained unit that heats the water, dispenses a programmed amount of milk replacer, mixes the milk replacer and water in a container from which the calf can suck it out through a nipple feeding station. Calf autofeeders involve the basic components shown in the illustration below (Biotic Industries, Bell Buckle, TN).
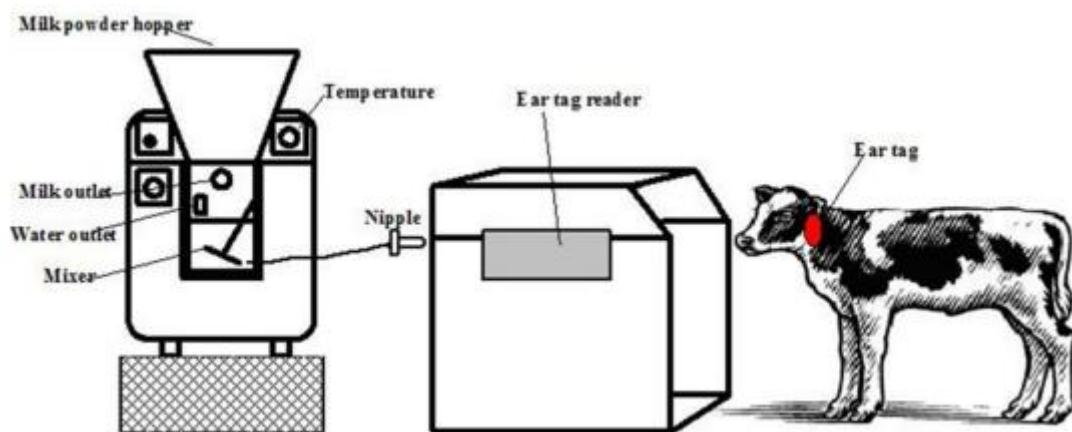
Basic component of automatic calf feeders (From: Biotic Industries, Bell Buckle, TN)

These systems vary widely in sophistication and price ranging from systems which record minimal data and have simple feeding programs to more involved systems with extensive capabilities to program different feeding plans for individual calves in a group and monitor calf performance. The essential features of autofeeders include a feeding stall and feed box which contain a device enabling electronic identification of calves. Most new systems utilize the radio frequency identification (RFID) ear tags. The nipple is connected via a flexible tube to a mixing bowl where defined amounts of powder and water are mixed as prescribed by the system. Calves are limited by meal size, number of meals per day and time intervals between meals.
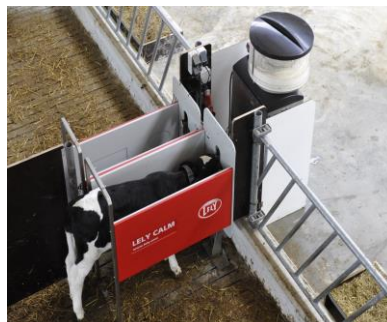
DeLaval CF500 -1000

DeLaval calf feeder CF150

Holm & Laue, Germany

Lely Calm

CalfRail, automatic feeding system, Forster-Technik

Advantages of automatic calf feeders:

- Improvement of the calf health and the quality of development due to the automatic calf feeders, which give continuous milk access and allow calves to feed according to natural instinct;

- The preparation of a fresh milk diet any time a calf calls with precise quantity, composition, and temperature;

- Administration of feed additives with minimal doses can be added to the milk diet in order to stabilise the gastro-intestinal system. Medicines can be added to the milk diet of sick calves, or electrolytes and water can be supplied with a specific dietetic programme;
- Decrease of work time;
- Adjustable milk/powder ratio (strength of milk adaptable) allows weight and health monitoring for each calf, and supports natural weaning process.
- Provides important information through the use of the management software that provides all calf data in easily readable screens on a desktop or tablet PC;

Disvantages of automatic calf feeders:

- Housing young calves together in large groups, involves certain risks in terms of biosecurity because of a higher infection pressure.

Producing companies:

- Holm & Laue (Germany) - Automatic Calf Feeder and Milk Taxi pasteurizer and delivery system
- Biotic Industries (USA)
- Lely (The Netherlands) - Calm automatic calf feeder
- Förster-Technik (Germany) – VARIO smart**,** Compact smart automatic feeder;
- DeLaval (Sweden) - DeLaval calf feeder CF150X , DeLaval calf feeder CF500+ and CF1000+
- GEA (Germany) - DairyFeed J C400+, V600+ and V640+
- Urban (Germany) - MilkShuttle and CalfMom
- BouMatic (USA)

2. Robotic feeders

The systems automatically load, mix and deliver fresh feed all day, every day around the farm. They are comprised of a kitchen where feed is automatically pulled from various bays or bins and mixed in the mixer, which then delivers it to the feedbunk.

The location of the kitchen can be adjusted based on the farm layout. It can be added on to a barn or located in a separate building. Its position would allow for bulk bins or upright silos to feed directly into it.

Forages from bags or bunker silos will need to be delivered and loaded in the kitchen throughout the week. On average, the kitchen should be loaded every two to three days in the summer and every five days in the winter, if the feed was put up well. Traveling by overhead rail, one robot can feed 40 to 700 cows. The rail can be installed outside with a roof overtop for travel to other buildings.

Using a lift system, the mixer is capable of hoisting itself up and over gates. A feed pusher attachment can be installed to push up feed as it travels. There is also a carousel option that will direct the robot down different tracks. It mixes and delivers a certain amount of feed at certain times of the day based on the program set up by the farm.

The software has the ability to communicate with the farm's milking system software and will automatically update the number of cows in the milking pen and dry cow pen when a cow's status is changed. The feeding program can be accessed via a computer, smartphone or tablet.

Dairy cows have traditionally been fed concentrates as they are milked to supplement nutritional requirements not supplied by the forages. In smaller-sized herds, *feeding concentrates* usually require a considerable amount of labor. Automatic concentrate-dispensing equipment is available for use in stanchion or comfort-stall barns, but few producers have installed such equipment. On farms where concentrates are fed in milking parlors, the opportunity for individual feeding varies considerably, depending on the type of equipment and milking management practices.

With computer-controlled concentrate feeders, each cow wears a device aroud its neck for identification. As it enters the feeder head box, its specific number is read electronically and the amount of concentrate programmed in the computer's memory for it to receive is delivered at a rate it can consume before leaving the head box, usually about one-half pound per minute. The total concentrate allotment is not available upon one entry to the head box but will be divided usually into four or more intervals for the 24-hour period.

Depending on the brand and model, multiple feed-dispensing units capable of delivering from two to four different feeds to each head box are available.

Some systems include a cow calendar program that will generate reports listing days in milk, cows to dry off, cows to breed, that can be used in managing the herd. Certain systems also include another program that will automatically adjust the daily amount of concentrate each cow is allowed to receive. Adjustments are based upon days since calving, projected lactation curves, or programmed equations.
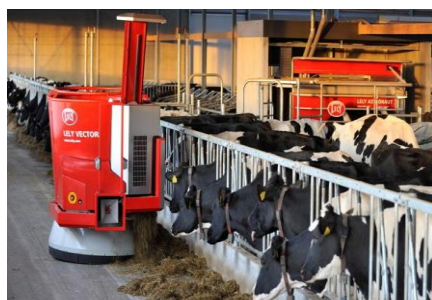

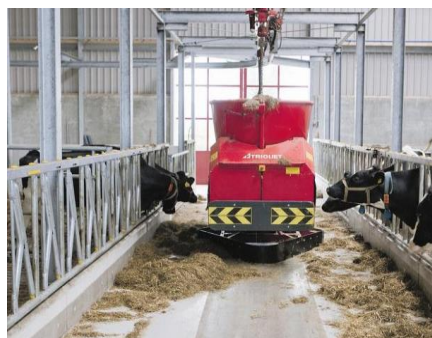*Pellon robot TMR*

Automated GEA MixFeeder

Lely Vector

Lely Vector

Triolet - Triomatic T25

Triolet - Triomatic T25

Nedap - Electronic Concentrate Feeding

Dairymaster - Feedrite

Advantages:

- Reducing working time;
- Moving from single to multiple feeding times has a positive effect on the milk yield, increases milk production and fat milk content. Frequent feeding ensures the right balance for each group of cows, depending on performance and stage of lactation. It also provides a more stable pH. Good stable pH determines less acidosis problems, higher feed intake (dry matter) and higher milk yielding;
- Well-balanced and mixed rations delivered through automated feed systems reduce feed separation as well as feed waste;
- Computerized concentrate feeder systems assures variations of the feed amounts containing different concentrate ingredients to each cow according to her individual requirements;
- Eliminate the need for a tractor to mix and deliver the feed;
- The energy costs, especially of electrical systems, are significantly lower than conventional feed mixers;

Producing companies:

- Lely (The Netherlands):
  - Lely Vector - Flexible fresh feeding
  - Lely Cosmix - Concentrate feeder for cows
- Trioliet (The Netherlands):
  - Triomatic HP 2 300 - Hanging feeding robot,
  - Triomatic WP 2 300 - Wheeled feeding robot,
  - Triomatic T25 - automatic feeding system
  - Triomatic T20 - automatic feeding system with stationary mixer
- DeLaval (Sweden)
  - DeLaval Optimat,
  - DeLaval Optimat Plus
  - DeLaval Optimat Master
- Pellon (Finland)
  - Pellon TMR Feeder Robot
- GEA (Germany)
  - DairyFeed C 8000 automated feeder ;
- Nedap (The Netherlands)

- Dairymaster
  - FeedRite (Ireland)
- Rovibec (Canada)

3. Rumination monitoring

Activity and rumination monitors are revolutionizing the way dairy producers detect heats and get early indications of health problems. Producers can monitor rumination time to anticipate potential health concerns before visual signs arise.The rumination monitor actually records the number of minutes a cow is ruminating each day by listening for sounds of rumination and cud chewing, or by monitoring the movement of the head with an accelerometer. If a cow ruminates less than her normal (each animal has its own baseline, but average 475 minutes per day), it's an indication that something is wrong.

There are companies that sell such neck collars or placed on the ear of the animal which are rumination monitoring systems combined with motion sensors. The basic principle of using sounds picked up by a microphone that is in tight contact to the cow's neck to measures rumination time.

The rumination data are downloaded to and stored in the herd computer after each milking or any time a cow passes under a tag reader, and is available as individual or group reports, produced by the herd management software. Rumination is recognized by analyzing the chewing sounds, and excluding the sounds related to eating.

The rumination time parameter may be applicable in two areas: nutrition management and health and cow's welfare sensor. Rumination data offers another key tool to make informed management decisions. The early identification of potential management challenges helps maximize efficiency and productivity, reduce potential milk production losses and raise the bar for animal health.

Advantages:

- Rumination provides a good insight into the activity and health status of the cow. Cows with displaced abomasum, ketosis, and metritis can potentially be identified earlier by the monitoring system than by farm personnel. Automated monitoring of rumination and activity is a useful tool to identify cows suffering metabolic and digestive disorders in dairy herds;

▪ Data can be converted into useable information for managing cows' health which give a real-time overview of each cow in terms of milk yield, lactation status and history.
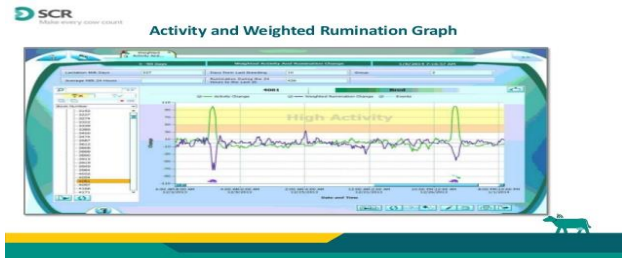
SCR Rumination Monitoring

The CowManager SensOor system

The Dairymaster MooMonitor+

SMARTBOW Eartag

Producing companies:

- SCR Dairy (Israel)
- Lely (The Netherlands)
- Agis Automatisering (The Netherlands)
- Smartbow (Austria)
- Dairymaster (Ireland)

6 References

4D4F is not responsible for the content on the external websites. All information was gathered online from the following websites:

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