Robotic Barn Design

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Take Home Messages

- Robotic milking will work in most barn layouts, but it will work best if cow comfort and convenient cow and materials handling are emphasized.
- A large open area in front of the robot and on both sides of selection gates, a pack area with robot access for fresh and lame cows, and robots that all face the same way contribute to cow comfort.
- A split entry holding area, perimeter feeding which allows use of a central handling facility, strategic use of post milking separation, pre-calving training, simple cow routing for fetching and strategic placement of handling and record keeping tools are design factors that will improve labour efficiency.
- Open alleys through the length of the barn simplify materials handling.
- With less need for labour, and a different work organization it is essential that all tasks can be accomplished by one person working alone.
- The capacity for a layout to accommodate logical expansion is also an important design criterion.

A Paradigm Shift

Robotic milking is one element in an emerging shift in direction for the modern dairy farm. It is only one of many examples of systems that use robotics to reduce labour requirements and that use sensor based data collection and computerized interpretation to reduce management requirements. Other precision technologies such as automation of feeding, robotic calf feeding, pedometers, rumination and temperature sensors, and in line sensors that measure components, and metabolic and hormonal parameters in milk will make it possible for a single operator to manage a much larger dairy. Some dairies using these technologies are producing 1.5 to 2 million litres of milk per person per year. But on other farms, failure to properly adapt both

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management and facilities means only a small portion of the potential benefits are realized.

■ Some Building and Renovation Principles

Milking robots are compact modular units that require minimal barn space. They can work in almost any location of a freestall or bedding pack barn, and they can be easily moved to a new facility in a later phase of expansion. But many renovations involve numerous compromises. Too often we become focussed on overcoming these challenges when the right decision might be to build new. Hence it is highly recommended that in the planning process every compromise be recorded on paper so that prior to construction a final review of the “renovation vs build new” decision can be undertaken.

The four goals or cornerstones that form the foundation of your building project should be cow comfort, labour efficiency, cost and value of the capital invested, and flexibility of the layout for future expansion. Since well managed robot milking barns require surprisingly little labour, almost every successful robot farmer will want to add more cows and machines within five to ten years. Hence the best barn plans will be easy to double in size while maintaining their simplicity and convenience.

■ One Way Gates

One way gates are used at the entrance to the holding area in a free traffic barn, in the crossover between the resting and feeding areas in guided traffic layouts. An “exit lane” one full cow length long with a one way gate at the end is recommended at the robot exit. The foot bath can be placed in this lane, but its main purpose is to let the cow exit completely before she has to deal with other cows in the barn. This reduces the likelihood that a cow will remain in the milking box after milking and also discourages other cows from approaching the exit side in search of feed. Ideally heifers should be trained to use these gates prior to calving by including one or more in the heifer barn. Saloon style gates consisting of two small gates either spring loaded or designed to close with gravity, will require less training than single bars that span the entire gap, with no opening. Vertical finger gates can be made in any width to provide a one way passage wider than a single cow and may be helpful when fetching several cows from a large group.

■ Training Cows for Robotic Milking

When starting a robotic milking herd, much of the labour of training cows can be eliminated if cows can have a few weeks of access to the milking box for

feeding only, while milking is continued in the parlor. By introducing several cows to the stall and the feed in it when time permits these cows will learn to use the stall and others will follow. Similarly an ideal barn layout will make it possible to provide easy access for heifers in the last three weeks prior to calving. Familiarizing them with the milking box, with the feed it dispenses and with all of its functions except actual attachment and milking, can greatly reduce the stress on the heifer at calving and the training time required at that time.

■ Cows Never Leave the Barn

The design of a robotic milking barn must recognize that milking cows never leave the barn. Hence it is never convenient to move cows through the space occupied by other groups, and it is important to locate groups strategically or provide lanes for cow movement. Since the logical labour organization of a robot barn seldom allows for two people in the barn at the same time, cow movement from group to group and to the robot or handling area must be set up to be a one person job. Moving through the barn with equipment to scrape manure or bring in bedding is also highly disruptive. Hence tractor scraping manure is not recommended. Bedding delivery is done less frequently and is a less serious issue but automated bedding delivery systems may still be a wise investment in robotic milking barns. Track systems that apply chopped straw or shavings to empty stalls are in development and flex auger systems with drop pipes which deliver sawdust/shavings to a central corner in front of four head to head stalls for manual distribution are in commercial use in Europe. Waterbeds or mattresses that require minimal bedding are recommended to reduce the need for bedding. Use of sand bedding will require moving through the barn with bobcats or tractors and to minimize the time involved layouts that create straight lines through the barn with doors at each end and layouts with free cow traffic, wide alleys and multiple crossovers that provide simple escape routes for cows when equipment passes through the alleys are recommended.

■ Focus on Cow Comfort and Healthy Feet

Both experience and research have shown that well rested cows with healthy feet visit the robotic milking stall voluntarily with the highest frequency. Contributing factors include big comfortable free stalls where feet can dry while the cow rests, floors that drain liquids away from the claw, and cleaning systems and layouts that keep cows' feet clean and dry. With respect to alley scarpers, short scraper runs, wide alleys and "V" scrapers allow the cow greater opportunity to step over the plow without stepping in manure and free traffic barns provide escape routes that help cows avoid the scraper. Stalls

and floors that provide good grip prevent injuries that contribute to lameness. Good ventilation promotes drier floors and drier hooves.

■ Make the Robotic Milking Stall Attractive to the Cow

Ensuring the area around the robot is free of stray voltage by slatting it, or by including an equipotential plane in the concrete is one step toward ensuring cows are comfortable in and around the robot. Ceiling fans above the robot help to cool cows in summer and keep flies away during milking. Rubber on the floor both in the robot and beside it will improve cow comfort as will positioning the stall so that entry is level or elevated 4 inches or less. In robotic milking stalls that restrict the cow's movement with a butt plate and adjustment of the feed manger, it is important to adjust these devices so the cow has adequate space in the stall and can stand comfortably.

■ Fetching Cows

Routing for fetching cows should be simple and logical, ideally so that this task can be combined with cleaning freestalls. When it is done this way fetching requires very little time, however the task grows exponentially if management breaks down and there are many cows to fetch. Gates at the robot and in crossovers should be designed to eliminate escape routes and it should be possible to close and open them along the fetch route without backtracking.

■ The Barn Office

Robotic milking will increase the amount of management time in the office, so a well designed office is an asset on these farms. Windows overlooking the area in front of the robot, the calving area and the outside approach to the barn will provide an excellent overview of the barn. Raising the floor 2 to 3 feet or sitting on a bar stool at a higher counter will improve the view. If you choose a second floor office build it on top of the milkhouse or over the handling area, so that you can see the area in front of the robots, rather than directly on top of a robot room, where the most important view is obscured. There are two distinct components to working with computer data. One involves sitting down for an extended period of time to manage data, and for this you want a clean comfortable work area with a good overview of the barn. The other involves looking up or inputting task related information, which you will want to do close to your handling area, standing up with boots on. Strategically locating a second computer terminal in the barn, near your work area will make these tasks much more convenient.

■ Free Or Guided Cow Traffic

Numerous research studies have compared these management strategies. Most agree with the findings illustrated in Table 1. As shown the shortcoming of free traffic is that cows are milked less frequently. Other studies also report that cows in free traffic barns are more likely to require fetching. In one Canadian survey (Rodenburg 2007) free traffic herds reported fetching 16.2% of cows while guided traffic herds fetched 8.5%. In some cases fetching a new cow in a free traffic setting can be an early warning of health problems, while such a warning may come too late in a guided traffic situation. Although cows in guided traffic barns were milked more frequently, the shortcomings of this system involve long waiting times for milking, especially for timid cows and also fewer meals. In some herds, acidosis related to fewer meals and stress from longer standing times have contributed to a greater incidence of lameness. Robotic milking equipment and the management around it have improved in recent years and field experience shows us that excellent results can be achieved with either system. But when management is less than ideal, with guided traffic the cow suffers the consequences, while with free traffic it is the farmer who is most affected. While there is clearly room for personal preference and priorities in this choice, when the choice is between giving priority to labour efficiency or cow comfort I will choose for cow comfort and hence for free traffic.

Table. 1. A Comparison of Cow Behaviour with Free and Guided Cow Traffic (Thune et al. 2002)

	Free	Guided	Guided (with preselection)
No. milkings	2.0	2.6	2.4
No. of meals	12.1	3.9	6.5
Average time waiting at robot (minutes/day)			
Dominant Cows	78	140	124
Timid Cows	95	240	168

■ Space in Front of the Robot and on Both Sides of Selection Gates

A decade ago the basic philosophy in robotic barn design was to guide or funnel the cows toward the robot, by placing it along a route from the freestalls to the manger and eliminating escape routes using gating and narrow passages. Field observation in these barns established that timid cows that required fetching seldom approached the robot voluntarily. Newer

barn designs for voluntary milking provide a large open area 20 to 24 feet wide measured from the face of the robot, with access to both alleys, where cows can congregate without fear of entrapment. It would appear that orientation of the robot within this space is unimportant as long as cows can easily see it and the space in front of it, from their resting and eating areas. Since the area near the robot will be populated by cows waiting for milking, computer feeders and cow brushes do not belong in the same area. With the exception of a water trough, other devices should be placed in open areas far from the milking stall.

Just as a large open space in front to the robot is beneficial, guided traffic barns should be planned so that there is open space on both sides of selection gates making cows more confident about approaching them. In rare cases where it is desirable to position cows in a consistent order a single lane will be preferred. One example of this would be a priority lane used only for a small number of timid cows which offers preferential access to the guided traffic milking stall.

■ The Robot Room

Many popular barn layouts feature robot rooms that include more than one robot. While this is convenient for cleaning and servicing it has several disadvantages. Air and vacuum leaks and straining bearings and joints can often be heard before they can be identified in any other way, and they will be recognized and located much easier in a room with a single robot. Both the option to access a robot from more than one barn area and the option of post milking separation become more difficult when there is more than one robot in a room. Back to back robots on a single room will remain the preferred option with the system that services two mirrored milking stalls with a single commercial robot arm, and while post milking separation remains an option with this layout as well as with tail to tail robots, neither of these layouts permit routing that allows further milking visits for the separated cow. Robot rooms housing a single robot allow much greater flexibility in application.

Robot rooms should be ventilated with positive pressure, constructed of easily cleanable surfaces and provided with clean access. An exit door large enough for a cow is recommended since cows have occasionally found a way in. The area around the robot room should be well lit, and equipped with a boot wash and man passes that permit easy movement around the area. Normal work routes through the barn should not require passage through the robot room.

The Holding Area

With free traffic layouts a holding area for fetched cows is still required. An area of 80 to 100 square feet suitable for 4 or 5 cows is recommended for use with a single robot. In order to encourage cows to leave it quickly, the holding area should not have access to water, feed or freestalls. Gating is required to direct fetched cows into it with no escape routes. In free traffic barns permanent holding areas or commitment pens which all cows must access prior to milking create additional stress on low ranking cows who may spend long periods in the holding pen. Temporary holding pens, some with gates that are removed automatically when the last fetched cow is milked, have been used successfully. But the best option by far for holding and training fetched cows in a free traffic barn is the split entry holding area pioneered by DairyLogix. As shown in Figure 1 the holding area is used only for fetched cows that access the robot via a lane immediately beside the milking stall. Cows from the main barn area can still access the robot at the same time via the split entry feature.

Using this system, timid fetched cows are not stressed by boss cows coming through the holding area. Using the crowding gate attached to the corner of the robot room, one person can easily crowd a new heifer into the robot entry area and push her in for her first visit. Subsequently the heifer can be cornered by this same gate with a chain behind her to encourage her to go on her own. This can be followed by voluntary entry from the holding area which gives her a slight advantage since the robot opens to her first, and later she will likely move on to complete voluntary attendance quite quickly. Since cows in the herd have access even when fetched cows are in the holding area, the farmer can leave the barn. With other holding area designs that deny access to cows in the main herd, most farmers will end up pushing a reluctant fetched cow into the robot thus teaching her more bad habits. Split entry holding areas can also be used effectively to permit access to the robot from a separate group housed behind the robot. Farmers who have a calving pen behind the robot benefit from this layout because it is easy to move the fresh cow to the robot for milking. They benefit again when the cow is in the main herd and returns to the holding area in search of her calf.

Special Needs Area Behind the Robot

After calving it may be beneficial to keep the fresh cow separate from the main herd for 1 day to two weeks depending on her health and condition. Lame cows also benefit from separate housing to shorten their walking distances and permit greater rest in a lower stress environment. Ideally these cows should be housed in a well bedded pack area with 100 square feet of pack per cow. If this area is close to the robot and offers voluntary access

many of these cows will go for milking on their own. If they do not, fetching them involves minimal time and walking distance for both the cow and the operator. This is probably the first and most valuable use of the “second group” option.

■ Handling Cows in a Robot Barn

Handling cows in a robotic milking herd for breeding, pregnancy checking, vaccinations, treatment, clipping hoof care etc. presents very unique challenges. In parlor herds, cows receive close scrutiny in the parlor, and they can easily be identified and sorted from the herd over a short time span in the return lane. Since they are hungry after milking, when they return to the barn they willingly lock themselves into headlocks for handling at the manger.

In a robotic herd, milking times cannot be predicted, so sorting a cow or group of cows at milking will require up to 15 hours of lead time. Hence a good sort pen must provide the sorted cow with feed, water, a place to rest, and ideally the opportunity to return for additional milking. Headlocks for robot barns are equally problematic because without a period away from feed many cows are not interested in going to the manger when fresh feed is delivered. As a result many robotic milking herds do treatment work by crowding cows into freestalls, chasing them into headlocks, or fetching them into the holding area strictly for timely separation. This aspect of robotic milking management is perhaps the least well defined in terms of what is an ideal handling system that minimizes operator labour and stress on the cows. Although experience with such systems is limited, barn designs that include a large separation area offer the best potential solution. This area must be designed so that cows can be directed to it from all robots, and so they can be housed for 12 to 15 hours with access to feed, water, a freestall and additional milking, and so that they can be handled in a convenient working chute before returning to their main housing areas. This handling area should also incorporate excellent lighting, equipment storage, hot and cold water, and a desk and computer for dealing with treatment records.

If dry cows are also housed behind the robots a freestall area with flexible gating that can be moved could be used to provide a lot of dry cow space and a few separation stalls on days when minimal sorting is taking place, and with the gates relocated, this same area could crowd the dry cows for 12 to 15 hours on days when a large group is being sorted for example for pregnancy checking. This is probably the second most valuable use of the “second group option”

A third use of robot access from a second group would be to allow voluntary lead feeding and training of heifers and inexperienced cows prior to calving as discussed earlier. In a barn with three or more robots in individual rooms

surrounding a central handling area, all three applications can be included.

■ Perimeter Feeding

Moving cows from several different groups to a central handling facility or to a separation area is simplest if cows do not have to cross a feed alley in the process. Hence robotic milking barns lend themselves well to layouts with perimeter feeding and all cows and robots located centrally. Perimeter feeding also keeps rain, sun and frost out of the cow areas further enhancing cow comfort. Some perimeter feeding barns have attempted to feed across the ends of the barn as well, but lost manger space in the corners, and at entry gates and the need for additional crossover width to accommodate water troughs across from mangers makes this somewhat impractical. It is advisable to include a 6 foot wide alley across each end to permit crossing over inside the barn to push up feed with a garden tractor or automatic feed pusher.

■ Robot Orientation

In a field survey of 11 herds in the Netherlands and 1 in Canada, where cows could access more than one robotic milking stall, it was found that with a variety of layouts 39% of cows used both robots 40 to 60% of the time, defined as “cross use” and 20% of cows used either one or the other robot more than 90% of the time defined as “selective use”. In a comparison of layouts it was found that selective use was lowest when all robots faced the same way (Gerlauf et al. 2009). We have also observed that when cows are moved from one group to another they adapt much easier if the robot in the receiving group is oriented the same as their previous experience. Hence we recommend that all robots in a dairy be oriented the same way.

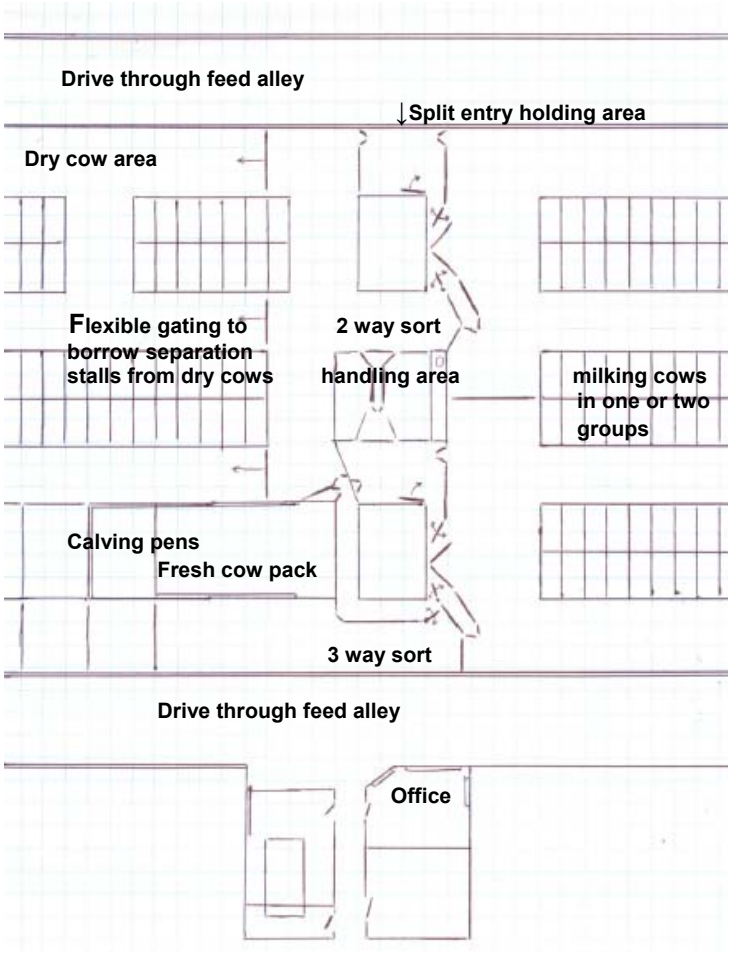

Figure 1. The robot and handling area of a 2 robot barn

■ Group Size and Grouping Strategy

Although a growing number of herds have experience with group sizes ranging from up to 60 cows with one robot to up to 180 cows in a single group accessing three robots, there are no really clear answers on what is ideal. Similarly herds that have the option to group cows may opt for early and late lactation groups, first and later lactation groups or they may include animals of all ages and stages of lactation. Benefits of keeping groups small and accessing a single robot include easier identification of fetch cows and easier fetching, more stable and simpler group dynamics and higher recognition of all group mates by cows. Benefits of two robots in a group include shorter

waiting times and less disruption from washing or maintenance work. Benefits of three robots include simple barn layouts in bigger six row barns. Benefits of grouping by stage of lactation include reduced grain feeding in the TMR to lower producers, allowing more feed in the robot and better attendance, and the ability to reduce feed cost and prevent over conditioning. Benefits of grouping by age include more uniform cow size and the option to vary stall sizes accordingly. Since the answers to these questions are not entirely clear, flexible layouts that permit variation in grouping strategies may be preferred. Perimeter feeding also increases the ability to vary group size.

■ Putting it All Together

Figure 1 presents a free traffic barn layout that includes many of the capabilities discussed above. In order to illustrate handling areas in a larger scale the ends of the barn are not shown. As illustrated in Figure 2 this basic two robot barn can be expanded to up to 4 robots while retaining its handling area at the left end. By mirroring this barn to the left 8 robots with central handling are possible. A number of barns have been built using this basic "DairyLogix" design for 2, 3 and 4 robots in Canada, the Netherlands and Finland. It is our goal to learn from the experiences of these producers and to continue to refine the concept to further enhance labour efficiency and cow comfort as we continue our quest for the ideal robotic milking barn.

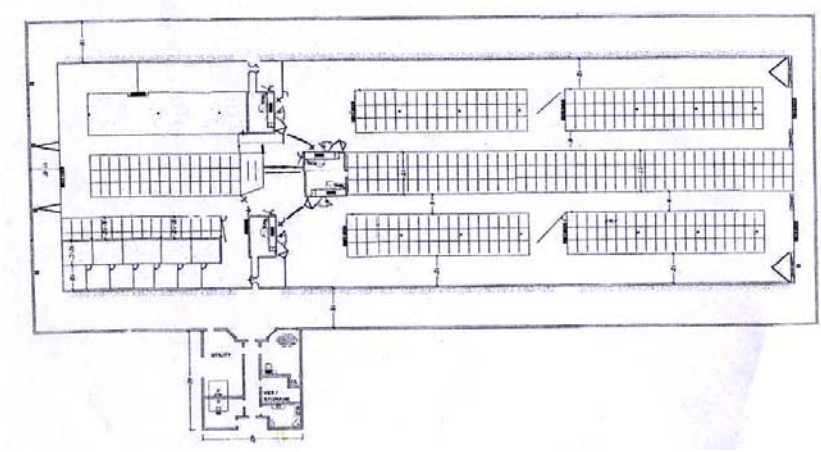

Figure 2. A 4 robot layout with handling and special needs on the left and two groups of 120 milking cows on the right.

References

Gerlauf, J.S, G.J. VanderVeen, and J. Rodenburg. 2009. “Preference Behaviour of Cows Choosing a Robotic Milking Stall”, in Abstracts of the 2009 European Association of Animal Production, Wageningen Press. See http://www.eaap.org/Barcelona/Book_Abstracts.pdf

Rodenburg, J and H.K. House. 2007. Field Observations on Barn Layout and Design for Robotic Milking, in Proceedings of the Sixth International Dairy Housing Conference, Minneapolis, ASABE Publication Number 701P0507e.

Thune R.O., A.M. Berggren, L. Gravas, and H. Wiktorsson. 2002. “Barn Layout and Cow Traffic to Optimize the Capacity of an Automatic Milking System” in Proc. Of the First North American Conference on Robotic Milking, Wageningen Press.