Optimal Design for AMS Barns

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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 handling of cows and materials are emphasized.
- Free cow traffic provides a higher standard of comfort for cows, especially for cows with lower social rank.
- 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 that 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 improve labour efficiency.
- Open alleys through the length of the barn simplify materials handling.
- Foot health is key and should include a good foot bathing routine either in a sort lane at the parlor exit, or in a remote crossover strategically combined with bedding the free stalls.
- 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 an important design criterion.
- Large dairies should consider 3 robots per group, small “just in time” handling areas, and a fresh group for not more than the first 3 to 4 weeks of lactation.

Main Stream Technology

I last spoke at this meeting about barn design for robotic milking in 2010. At that time the number of robotic milking barns was estimated at 9,000 worldwide. Just 6 years later in 2015, that estimate is 25,000, or more than triple in 6 years. Robotic milking is one element in an emerging shift in direction for the modern dairy farm, which includes use of robotics in automatic feeding, bedding and calf feeding, and precision tools like pedometers, rumination, body condition imaging, and in line sensors that measure components, and metabolic and hormonal parameters in milk to reduce management time requirements. These technologies will make it possible for a single operator to manage a much larger dairy, producing 1.5 to 2 million litres of milk per person per year. But on many farms, failure to properly adapt both management and facilities means only a small portion of the potential benefits are realized.

Many of the recommendations I made here 6 years ago are still the same, and it is gratifying to see research validating them and producers implementing them successfully around the world.

General Building and Renovation Principles

Milking robots are compact modular units that require minimal barn space. They can work in almost any location of a free stall 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 focused on overcoming these challenges when the right decision might be to build new. In the planning process, every compromise should be recorded on paper so that prior to construction a final review of the “renovation vs. build new” decision can be undertaken.

The 4 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. While expansion in our supply managed industry is not always easy, the best paper barn plans start with a facility that is twice the size of your current needs. This plan should then be scaled back to the current project in such a way that all the capabilities for grouping, sorting and handling are there now, and will continue to work in an expanded version.

Choose Free Traffic with No Commitment Pen

There are no good layouts that can be converted from one traffic option to the other, so the decision to choose free or guided traffic must be made early in the planning process. Three common variations of “cow traffic” strategies are considered viable options today: 1) free cow traffic, where cows can access feeding and resting areas of the barn with no restriction; 2) milk first guided cow traffic with pre-selection; and 3) feed first guided cow traffic with pre-selection. In guided traffic options, one-way gates block the route from the resting area to the feeding area for milk first, or from the feeding area to the resting area in feed first to prevent cows from passing freely between the two areas of the barn. Pre-selection gates located away from the milking stall refuse passage to cows eligible for milking and a pre-selection gate beside the robot directs these cows into the “commitment pen”. Since cows need to spend time in both the resting and feeding area, this restriction is used to “force” them to visit the robot.

The single advantage of guided traffic is that when the cow’s options are to go through the robot or starve, she chooses survival and generally goes through at least twice a day to allow access to both areas of the barn for most of the day. Thus, there will be fewer cows to fetch and less fetching related labour. In free traffic barns, the feed in the robot is the only attraction, so minimizing the number of fetch cows requires emphasis on feeding a good quality pelleted concentrate there. With guided traffic the importance of pellet quality is lower. Since the time budget of the cow calls for 14 to 16 hours of rest and only about 4 hours eating, milk first guided traffic is the more logical of the two guided options.

One disadvantage of guided traffic is reduced cow comfort because of longer waiting at the robot entrance, especially for low ranking cows, because bigger cows continually push them aside and enter the robot ahead of them. This happens in free traffic barns as well, but there, the cow has the option to go and eat or lie down and come back at a time when the robot is less busy. When guided traffic robots are at or near capacity, some timid and weak cows stand in the commitment pen 3 to 4 hours per day waiting for milking, increasing the risk of lameness; they also eat fewer meals increasing the risk of rumen acidosis. Since the cows affected by this are the timid heifers, the fresh cows and the weak and lame cows that are already compromised by their condition, the comfort and welfare of these cows is clearly poorer in guided traffic barns.

The added gating needed for guided traffic also adds cost and makes going through the barn with equipment for bedding etc. more complicated. It should be noted that a new fetch cow in a free traffic barn can be a way to identify a new case of clinical mastitis, a new sore foot, or a cow in heat, but in guided traffic these cows will continue to visit unless the problem is severe. A study of 635 Lely robot herds in Canada and the U.S. reported higher production per cow and per robot with free traffic (Tremblay et al., 2016). The two main robotic milking companies have quite different recommendations for guided vs. free traffic. Since both have 20 years’ experience, this is not likely to be purely opinion, and it suggests that there are differences between the systems that lead them to their preferences.

The commitment pen mentioned above is a gated area in front of the robots that cows cannot leave until they have been milked. It is accessed via a one-way gate or a pre-selection gate. Cows leave the pen either through the robotic milking stall or through a selection gate that only allows them to exit after milking. This pen is common to guided-traffic barns. It is also used in some barns that do not restrict movement from the resting area to the feeding area as a way to force fetched cows through the robot and to sort cows to different areas of the barn after milking. While the latter is traditionally considered to be a free traffic barn, once the timid cow enters the commitment pen she faces the same situation as with guided traffic, so this pen decreases cow comfort. Although I have not seen it done, a milk first guided traffic barn with no commitment pen would at least allow the cow to go back to a free stall if she had to wait too long, and this is an option worth considering.

■ Handle Fetch Cows in a 'Split Entry Fetch Pen"

Every robot barn needs a way to hold fetched cows in a pen that forces them to go through the robot, and the best option for that is the "split entry fetch pen" illustrated in Figure 1. Cows herded into the pen because their milking interval is too long push the free-swinging gate at the robot entrance one way to enter, while cows from the main herd still have access by pushing it the other way. Since the robot gate opens first to the fetch pen side, cows in the pen have a slight advantage, but traffic in the main barn is not totally disrupted by the fetch cows. Gate E in Figure 1 makes this pen a good learning environment since a new heifer can be brought into the pen, and with gate E pulled up beside her, she can be pushed into the robot safely by one person. On a subsequent visit, gate E can be chained behind her to the main gate of the fetch pen to hold her at the robot entrance until she goes on her own. In the final training step, she goes on her own from the fetch pen before she is left to enter from the main herd. In a recent Dutch study (Heurkens, 2015) of 127 Dutch dairy farms with robots, the use of a split entry fetch pen was associated with higher production per robot.

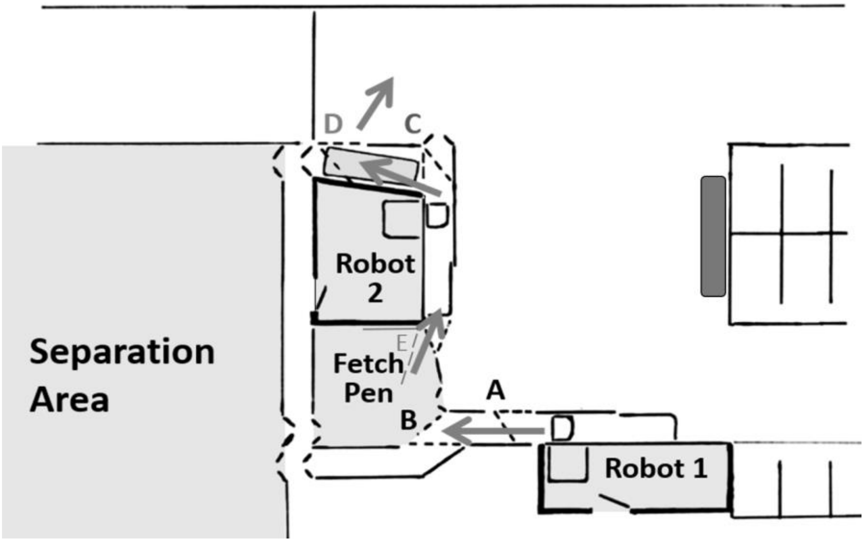

Figure 1. An illustration of 2 robots in an "L" layout with a "split entry fetch pen" with training gate E. Cows are diverted to the separation pen from robot 1 via gate A and B and from robot 2 via gate C and D. The foot bath is located between gates C and D. Cows from robot 1 access the footbath along the route marked by arrows, via gate A and B through the fetch pen and a refusal in robot 2 and through the footbath via gate C and back to the barn via gate D.

■ Design to Minimize Lameness Incidence

Lame cows visit the robotic milking stall less often resulting in lower milk production and an increased likelihood of fetching. Barn design and management risk factors associated with a higher incidence of lameness include high stocking density, limited bedding on mattresses rather than deep bedding or sand, free stalls that are too small and restrictive, high curbs on free stalls and crossovers, slippery alleys, inadequate drinking space, and low frequency of foot bathing.

Even though bedding delivery with skid steers and slingers disrupts the cows, deep bedding systems with sand or chopped straw/lime/water mixtures are a better choice than mattresses to encourage long resting times, and injury free rising and lying down. Adequate space in the free stall, which for a Holstein cow means 48 inches wide, 10 feet long to the wall and 17 feet long for a double head to head platform with a neck rail and brisket locator at 70 inches from the rear curb, will encourage cows to spend more time lying in stalls. Neck rails with a forward bend in the center of each stall are an interesting innovation that encourage cows to lie straighter. More rest means less pressure and drier feet resulting in less lameness. A maximum curb height of 8 inches in the stall and 3.5 inches in crossovers is recommended, as is grooving floors to reduce slipping. Wider alleys improve cow comfort and decrease the manure exposure of the cows' hooves. Alley width along the manger with a stall backing onto the alley should be 14 feet, the alley between two rows of stalls should be 11 feet, and an alley along an outside wall should be 10 feet for best results. Tractor scraping a robot barn is too disruptive so slatted floors or alley scrapers are the only options. Slat barns should be cleaned with a robotic slat scraper.

Traditional alley scrapers in solid floor barns contribute to lameness by exposing cows to a moving manure bath on each pass of the scraper. Locating manure drops at the end of the barn furthest from the robots, not overstocking, offering multiple crossovers, frequent scraping, the use of a tube scraper system and the use of feed stalls at the manger reduce the exposure of cows to this manure. Recent development of a robotic scraper for solid floors with a vacuum tank that transports manure to a manure drop at the charging station offers a new option for cleaning solid floors including crossovers.

To deal with lame cows, robot barns should offer a low stress pack area where lame cows can recover, and a good chute to examine and treat foot problems. Ideally someone involved in day to day management of the herd should have some expertise in basic hoof trimming and treatment.

▪ Develop a Foot Bathing Strategy

The strategic use of a footbath is important in preventing lameness, but it presents special challenges in robot barns. Footbaths placed in the exit lanes of the milking stalls reduce the number of milkings, either because cows are reluctant to visit the robot with the footbath present or because longer exit times reduce available free time. This location also results in frequent visitors getting many more passes, which may be detrimental for them and increases cost of the chemicals used.

A preferred method of foot bathing uses a bath 10 to 12 feet long located in a remote crossover. In a one-robot barn, this bath can be one cow wide, but for larger groups it should be the full width of the crossover. A hinged bath can be stored vertically at the end of the row of free stalls, and lowered and filled when needed. Once filled, the cows are herded through the bath slowly once or twice a week. Although this does disturb the cows, it keeps harsh chemicals away from the milking area. With less manure exposure, chemicals work better and there is a uniform number of passes per cow. In herds where bedding or grooming stalls requires moving cows around anyway, foot bathing in a crossover can be done strategically at the same time. The minimum amount of “herding” results from filling the crossover bath at the start of the day, closing all other crossover gates and moving the cows in the manger alley and in the adjacent stalls through the bath to the other alley; then bed the empty stalls along the manger, deliver fresh feed and release the cows to the manger alley through the bath, herding up any stragglers before bedding the back two rows and opening all the gates back up. Foot bathing cows housed behind the robots, which often includes the lame cows, is difficult with this approach, but with an extra gate in the back alley these cows can be brought up though the manger alley, reversed after the bath and sent back to their pen.

The third and probably ideal option is to locate the footbath in a separation lane beside the robot exit as shown in Figure 1. This allows more strategic use since individual cows can be sorted through the footbath with computer-controlled frequency, and it requires no labour beyond filling the bath and programming the computer; this would be a good place for an automatic footbath. In Figure 1, cows are routed through a second robot to access the foot bath, and while this should decrease milk per robot because each refusal slightly reduces the time available for milking, Heurkens (2015) reported that this feature was associated with higher production per robot, suggesting the benefits of separation outweigh the time lost for the refusals.

▪ Cows Never Leave the Barn

One of the differences between robotic and parlor milking is that cows never leave the barn. To avoid moving animals through other groups, the layout should place milking cows on one side of the robots, separation cows and fresh and lame cows on the other side, and then close up and far off dry cows and perhaps growing heifers behind them. Moving through the barn with equipment for bedding or grooming stalls is disruptive so automated bedding delivery may be a wise choice. Free traffic, wide alleys and multiple crossovers provide escape routes when bedding and grooming equipment passes through the barn.

▪ Open Space and Escape Routes Increase Milking Frequency

Placing the robotic milking stall beside a crossover with at least 20 feet of open space to the first free stall provides space for timid cows to wait without feeling threatened by the boss cow. This space should have an “escape route” on both sides so cows are not “boxed in” while waiting. With dual box systems milking from the rear, it is tempting to face the stalls into the milking group to provide simple clean access, but if this forces the cow to wait for milking in an area with only one escape option it may decrease milking frequency. Heurkens (2015) indicated that barns with more than 15 stalls to the first crossover, and barns with dead end free stall alleys produced less milk per robot, suggesting that ease of movement throughout the barn is important. Other devices such as cow brushes, computer feeders and exits to pasture should be far away from the robot to draw cows not waiting for milking to other areas of the barn. At the robot exit, an “exit lane” one cow length long with a one-way gate at the end reduces the frequency of delayed exit by timid cows because they can leave the robot quickly and still be protected from other cows allowing them more time to decide when to leave the area. This lane prevents cows from approaching the exit side of the robot in search of pellets.

▪ Make Cows Comfortable in the Milking Stall

When cows are comfortable in the milking stall, milking frequency will be higher and fetch cows fewer. A fan above the entry point, moving air over the cow from the rear, will cool the cow in hot weather and keep flies away during milking. Rubber flooring in the milking stall and a level entry also increase comfort. Steps should be taken to avoid stray voltage. If the area around the robot is slatted, cows will not be grounded so this is one option. With a solid floor, the area near the robot should include an equal potential plane bonded to the robot. In robotic milking stalls that restrict the cow’s movement with a butt plate and indexing of the feed manger, adjustment so the cow has adequate space in the stall to stand comfortably will improve voluntary visiting frequency. Locating the robot so it is highly visible from the barn will help timid cows decide when their visit is most likely to be successful.

▪ Put Fresh and Lame Cows in a Pack Area

After calving it is beneficial to keep fresh cows separate from the main herd in a comfortable low stress bedding pack for one day to one week, depending on their health and condition. Lame cows also thrive and heal here with shorter walking distances to the robot, less competition from other cows and ample manger space. This is the first and most valuable use of the “second group housed behind the robot”. Space allotment should be for 4 to 6 cows per robot, or 480 to 720 sq. ft. In the Heurkens (2015) study, the presence of, and size of the straw pack were associated with higher milk yield per robot and higher milk yield per minute.

▪ Handling and Treatment in Robotic Barns

Handling cows for breeding, pregnancy checking, vaccinations, treatment, clipping and hoof care is more difficult with robotic milking. Some herds do treatment work by walking around the barn to find the cows and crowding them into free stalls for treatment or examination; this is disruptive and time consuming and very costly, especially when a highly-paid veterinarian is involved. Since I am not convinced that robot farms have found clear answers for handling, I tend to include multiple options so producers and their veterinarians can explore different approaches. No examinations and treatments should ever be done in the robot because this needs to be a low stress place with minimal interaction with people. So, to breed, infuse, inject or examine, every robot barn needs the capability to direct individual cows exiting the robot to a separation area with easy access to a handling chute. Milking times vary, so sorting groups of cows at milking requires up to 15 hours of lead time before handling. Hence a good sort pen must offer the sorted cows access to feed and water, a place to rest, and the opportunity to return for additional milking.

Handling groups of cows for herd health, singeing udders or hoof trimming can be done with headlocks throughout the barn, or with headlocks, handling chutes or a management rail in a separation area. Headlocks throughout the barn are a very efficient way to perform specific tasks, especially singeing udders to remove excess hair. Most robot herds do this 4 to 6 times per year to increase the cleanliness of the udders and accuracy for laser teat location and attachment. But headlocks are somewhat problematic because in robot barns, without a period away from feed, some cows are less interested in going to the manger when fresh feed is delivered. Headlocks only work well if every cow can be locked up at the same time, so if there is insufficient manger space to do this, gating should be set up to lock back cows in the separation and fresh cow areas so that headlocks in front of these spaces can also be used for the milking herd during herd health visits or udder flaming. Except for flaming udders, handling cows in headlocks throughout always involves restraining and stressing cows you don't need to handle, and walking past cows that do not need to be examined, identifying those that do, and bringing drugs, records and equipment to the cow all takes more time and labour than dealing only with the cows that need handling. Dealing only with separated cows can result in a substantial time saving for herd health work. I also wonder if using the manger as a treatment area might be ill advised because this should be a welcoming area that cows are happy to go to often to eat large amounts of feed, and not a place that is associated with restraint and painful treatment.

Although experience with doing all handling in the separation area is limited, barn designs that include enough separation space offer the option of not using headlocks in the main milking cow area. Since many of the cows being separated will only spend a few hours in the pen, it is probably sufficient if there is space for about 60% of the final number to be separated. For group handling of separated cows, one option is to have headlocks in front of the separation and far off dry cow areas and lock back the far off dry cows and use these lock ups for handling. Cows unfamiliar with headlocks may avoid using them, but if they have seen them in the far off pen, a small amount of robot pellets should be enough to encourage all cows to lock in. Another option is two working chutes side by side with the herdsman releasing and loading one while the veterinarian examines a cow in the other. A third alternative is a management rail for handling cows in small groups.

The handling area should also incorporate excellent lighting, and provisions for equipment storage, hot and cold water, and records access. If a vet room is planned, this is one good location for it.

If dry cows are housed behind the robots, a free stall area with flexible gating can be used to provide a lot of dry cow space and a few separation stalls on days when minimal sorting is taking place. With the gates repositioned, this same area could crowd the dry cows for 12 to 15 hours on days when a large group is being sorted for reproductive exams, singeing udders or hoof trimming. Separation space is 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. This may be best done from the separation area on days when there are no separated cows.

Except for the BouMatic single box robot that milks from the rear, which allows cows to enter and exit on either side, single box systems that are used to milk a second group usually involve a ninety degree turn in the exit lane for cows going to the separation pen or straw pack. Since this is the likely exit route for fresh and lame cows, efforts should be made to make this turn as gradual and open as possible.

■ Perimeter Feeding and Manger Space

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. This also keeps rain, sun and frost out of the cow areas, further enhancing cow comfort. It is advisable to include an 8 to 10 ft. alley across at least one end of the barn to permit crossing over inside the barn to push up feed with a garden tractor or robotic feed pusher, or for feed delivery with a robotic system.

Since milking time is spread over the entire day, it has been suggested that there is less competition for manger space and for free stalls because a percentage of the herd is always waiting for milking. In a well-managed barn, the average number of cows waiting for milking is less than 5% of the herd, so any difference from the experience with parlor barns would be very small. While 3-row free stall areas in parlor barns do not offer a manger space for every cow, with a 20 ft. crossover in front of the robot, and a generous crossover at least every 15 stalls through the length of the barn, a robotic barn can be set up for six rows and 24 to 27 inches of manger space per cow. I have also designed 5 row barns with a single center platform with cows facing in each direction for half the length of the barn. While this works very well with two robots, expanding to four with a “double “L” is more difficult because of the narrow centre platform.

■ The Robot Room

Many popular barn layouts feature robot rooms that include more than one milking stall. While this is convenient for cleaning and servicing, accessing the robotic milking stall from more than one barn area and post-milking separation are more difficult with more than one robot per room. Back-to-back robots in a single room, commonly referred to as “toll gate” layouts, are the only option with the Insentec system that services two mirrored milking stalls with a single commercial robot arm, and with the BouMatic double box that features two stalls side by side serviced by a shared arm coming in between the back legs. While post-milking separation remains an option with this layout, routing that allows further milking visits for the separated cow can be challenging. Figure 2 illustrates a layout that does permit separation and milking of special needs cows, but this barn is limited to one group of cows; fetch cows and fresh cows have lower priority access; the long narrow lane impedes cow flow and is hard to clean; clean access to the robot room crosses the main return route and the milking stalls are less visible from the herd which increases the isolation of the cow from the herd during milking. Although there is no particular research evidence for this, some behaviorists suggest that cows prefer to be milked close to and within sight of their herd mates. Air and vacuum leaks and straining bearings and joints can often be heard before they are identified in other ways, and they will be recognized and located much easier in a room with a single robot.

Robot rooms should be constructed of easily cleanable surfaces and in some provinces, they need to be ventilated with positive pressure and provided with clean access. An exit door large enough for a cow is recommended since cows have occasionally found a way into the room. 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 elevation of the floor in the robot room is a matter of preference. Lower floors will require a curb along the milking stall so cows’ feet don't slip into the "pit". Dairymen choose this pit approach to make it easier for them to handle the udder, and manually attach the milker, but in terms of cow behaviour and stress free handling, cows milked robotically are no longer used to this kind of handling and it should be discouraged.

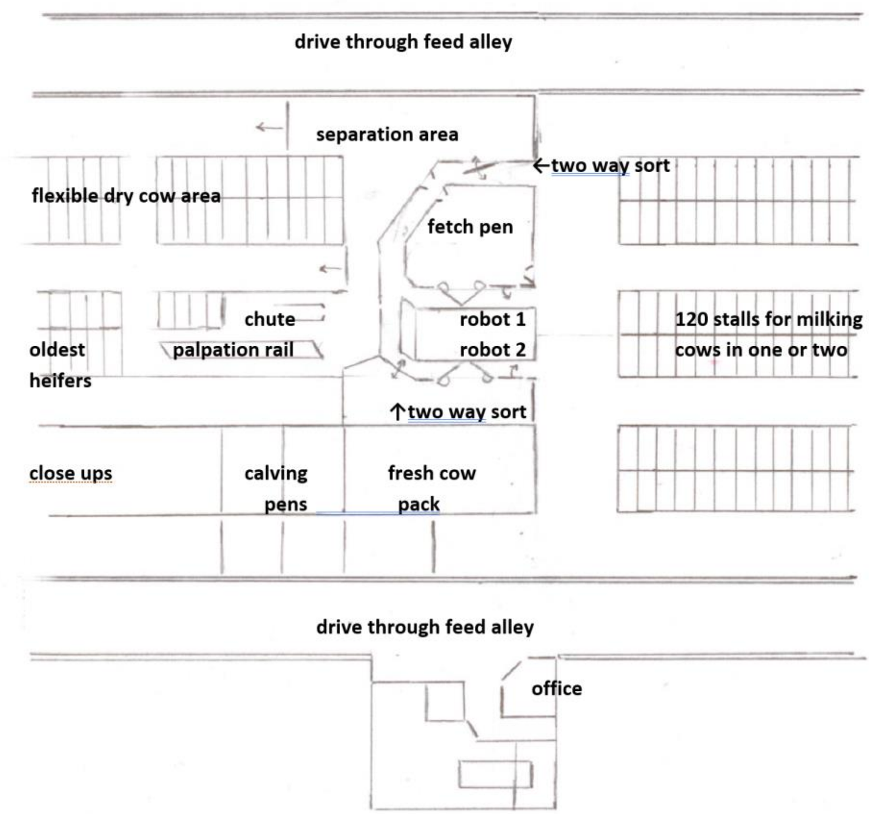

Figure 2. A layout suitable for robots that milk two cows side by side.

▪ Robot Orientation

When cows can access 2 robots they are less likely to show a preference for one over the other if both face the same way. Also, when cows are moved from one group to another, some cows adapt easier if the robot in the receiving group is oriented the same as their previous experience. Where it is practical to do so, I try to design barns so that all robots are the same orientation. Currently the way robot companies describe models as “left” or “right” is confusing. A “left” blue robot which is named so because it would be the same as a milking stall on the left side of a parlor when facing in the same direction as the cow, would be a “right” red robot named so because the arm comes in from the cows right. This and several other areas of robotic milking technology would benefit from more standardized nomenclature.

▪ Group Size and Grouping Strategy

Published analysis of field data shows higher production per cow and per robot in groups of cows that access 2 or 3 robots vs. 1 robot per group. Identification of fetch cows and easier fetching are the single benefit of 1 robot groups, so this option has merit if there is an expectation that there will be a lot of cows to fetch, but with 2 or 3 robots per group, waiting times are shorter and there is less disruption from washing or maintenance work. Simpler barn layouts with fewer gates also make moving through groups with equipment for bedding or grooming easier. Some larger herds group cows by age and size, and vary stall sizes accordingly. Very few herds group by stage of lactation. Doing so would require designing the barn with fewer stalls per robot for higher producing early lactation cows. Feeding a late lactation group a lower energy diet at the bunk would increase the interest of these cows in the robot pellet and decrease the number of late lactation fetch cows, but in general, very few herds move cows to other groups during lactation, presumably because ‘social stability” of the group is important.

▪ Good Gating is Critical

The logical labour organization of a robotic milking barn should not require two people in the barn at the same time. Cow movement from group to group and to the robot or handling area should be set up as a one-person task. Routing for fetching cows should be simple and logical, so that this task can be combined with cleaning free stalls. 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. One-way gates are used at the entrance to the holding area in a free traffic barn, and in the crossover between the resting and feeding areas in guided traffic layouts. 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. Since there is a lot of interaction between cows in the area around the robots, the risk of injury from protruding clamps and bolts is high, so this gating should always be welded rather than bolted.

▪ Expansion in “Modules” and Robotic Milking in Large Herds

There is growing interest in robotic milking in larger herds with 500 and more cows. Since robotic milking barns tend to be “modular,” the basic layouts and principles described here will apply to large herds as well. The example layout in Figure 3 starts with 2 robots to illustrate the importance of grouping the modules to permit central handling and minimum walking distances for people and cows.

An optimal 1-robot barn would be the right side half of the barn in Figure 3, with a far-off dry cow group in a single row of free stalls where the management rail is shown. These cows would have manger access in front of the lower half of the close-up group. This low cost, clear span building with drive through feeding on one side can be expanded to 2 robots in one 120-cow group by adding a second robot along the outside wall in the "L" formation shown in Figure 1. The single milking group can be further expanded to 3 robots by placing a second robot on the outside wall. A fetch pen between the two robots facilitates separation from the third robot via a refusal in the second, without creating a bottle neck. The final maximum size for this 3-row barn would be to mirror it on the opposite side of the pack and separation areas to create 2 groups of 180 milking cows accessing a central handling space.

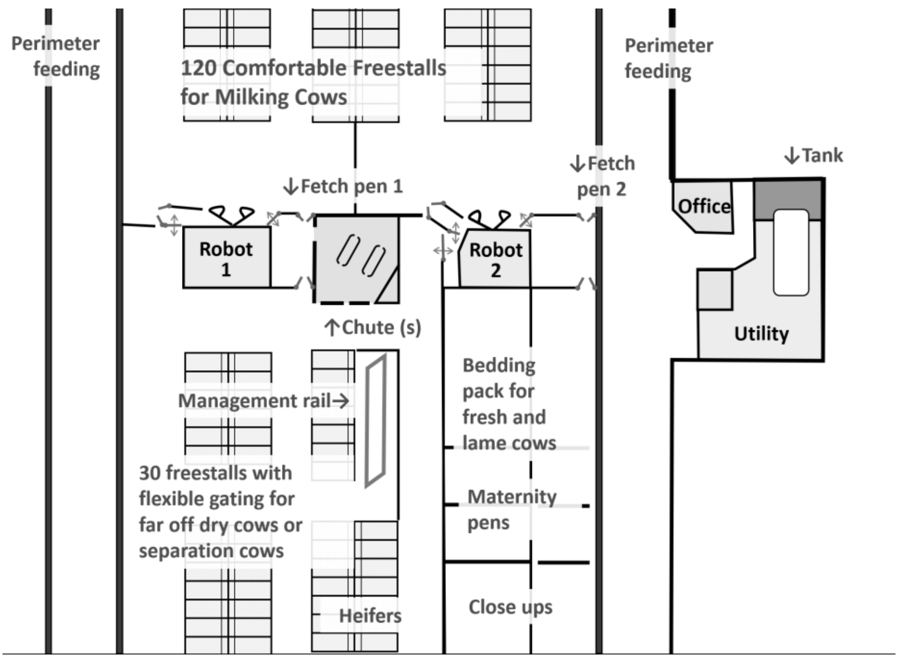

Figure 3. A six-row perimeter feeding barn with two robots, free traffic and all of the features described in the text.

In a 6-row barn with perimeter feeding on both sides, twice as many groups can access the central handling area, making this a much more labour efficient starting point for developing larger layouts. Using the barn in Figure 3 as the base, it can be expanded to 2 groups of 120 cows with back to back robots on the center cow platform creating 2 “L” configurations as shown in Figure 4. If this is done with 4 robots with the same orientation, separation from the one facing away from the handling area is done with a refusal through the robot beside it. Two lefts in one group and two rights in the other is a viable alternative that permits simple separation and foot bathing in the separation lanes. A left and a right in each group exiting toward each other also works well if foot bathing is done in a remote crossover.

This barn could be further expanded to 2 groups of 180 cows with 2 more robots on the center platform, and by mirroring the barn, it would house up to 720 cows in four “3 robot modules”. In the smaller barns the space behind the robots is typically used for separation, fresh and lame cows and dry cows. Once the barn is mirrored, such as from 2-120 cow groups to 4-120 cow groups, as in Figure 5, this space is fixed but this is not a problem since its use also changes. To keep central handling close together it is not practical to keep dry cows in the middle of a mirrored barn, so when the decision to mirror is made dry cows should be housed in a second barn parallel to the main barn with a link connecting to the separation area. At this stage milking fresh and lame cows in each robot is still the best option because it

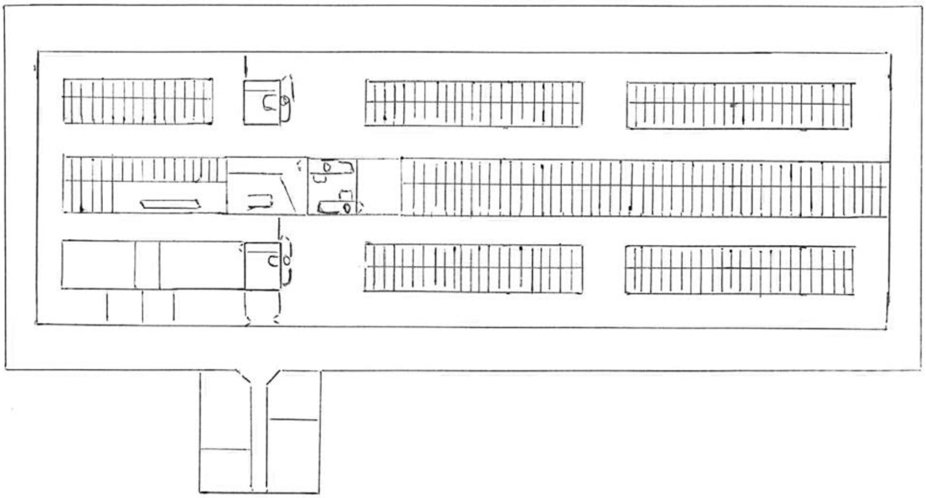

Figure 4. A 4-robot expansion from the 6 row 2 robot barn in Figure 3

spreads the high attention cows over multiple robots that are close together, and that is most efficient from a labour standpoint. In smaller herds, handling for most treatments is done once per day and herd health is done monthly, so separation areas must be relatively big. But as herds get bigger and there are people in the barn all day, it becomes beneficial to minimize the amount of time cows are out of their group.

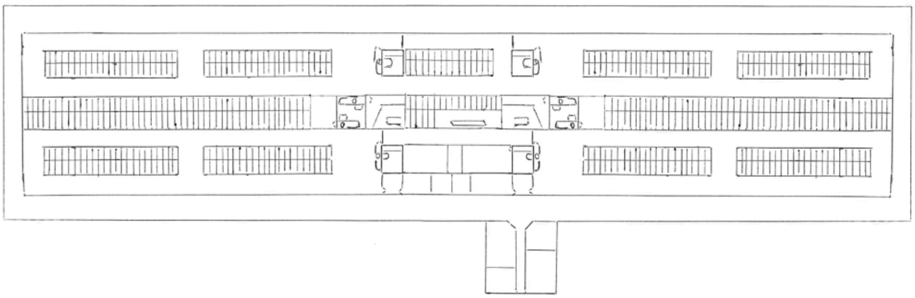

Figure 5. A mirrored expansion of Figure 4 to 8 robots. With 3 robot groups of 120 cows this layout can handle 12 robots and 720 cows.

Handling in these large herds is likely to evolve into having a herdsman rotate from group to group to deal with separated cows within a few hours after separation. This “just in time” handling can be done in the same 6 or 7 free stalls that were used for overnight separation in the smaller herd. The need for space for fresh and lame cows will increase with each expansion, so the fresh and lame bedding pack area will logically relocate to a dedicated “fresh and lame cow robot” with a bedding pack in front of it. The logical location for that would be in an extension of the dry cow barn near the close-up and calving area. The number of cows per robot in this area should be limited to about 40 to ensure there is minimal stress and ample free time. Lame cows could be brought back to this group from other robots to give them a place to recover in this high comfort environment.

Group changes are stressful for cows, particularly in a robot barn, where social hierarchy plays an important role in milking order so the period cows spend in the fresh pen should not be too long. It is probably best to move cows from this fresh group no later than 3 to 4 weeks fresh. To fill a robot with this group of cows will require a herd of about 400 milking cows with a fresh group of 24 to 28 cows fresh up to 3 to 4 weeks and 10 to 12 lame cows.

Modules with 2 robots per group in 4 corners limit the capacity of an individual barn to 480 cows, and with 3 robots per group, the limit is 720 cows. For herds larger than this, the most efficient layouts will include additional barns of this size parallel to the original barn linked by a central corridor for movement of cows, people and services such as milk lines, data cables, etc. as illustrated in Figure 6.

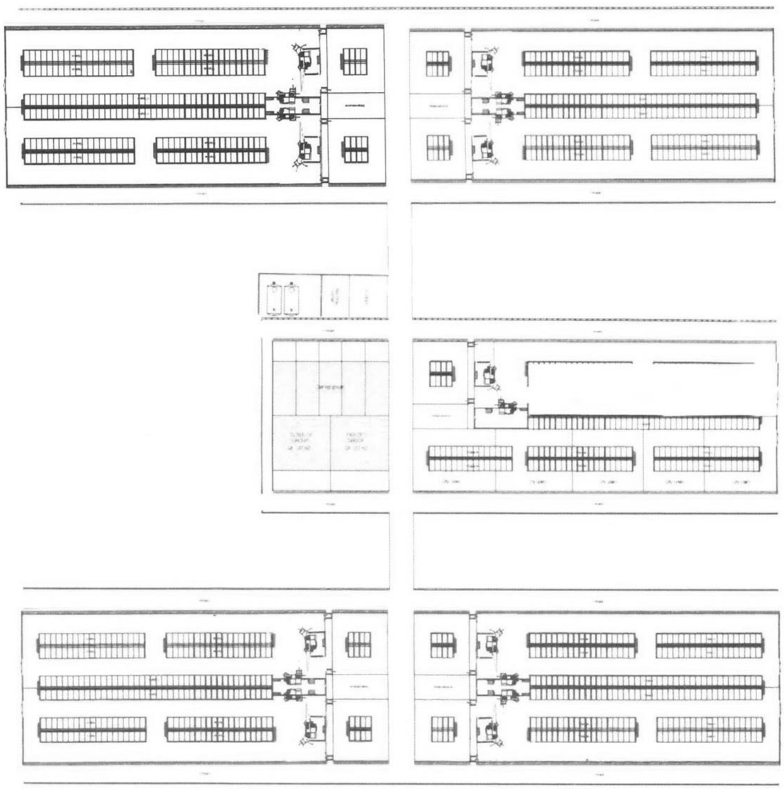

Figure 6. a layout with 2 – 8 robot barns with a third, central barn for far off and close up dry cows and two robots for fresh and lame cows.

■ Future Trends in Robotic Barn Design

The layouts discussed here are intended for free traffic robotic milking in typical North American confinement housing systems. As noted in the introduction, differences between these recommendations and those made 6 years ago are “fine tuning”, rather than grand changes in design principles. Looking to the future, if there are no big changes in technology and if our current production model remains socially acceptable and commercially viable, the potential for radically different barns is probably limited.

One of the benefits of robotic milking, especially in larger herds, is that cow welfare is improved because cows are no longer herded into crowded, hot and stressful holding areas three times a day for milking. The public perception of cow welfare is much enhanced by the freedom implied in voluntary milking, and as public concern over animal welfare increases, robotic milking may well be an important component of social sustainability for dairy farming. But big shifts in either technology or expectations could certainly have an impact on barn design. For example, if society demands extensive use of pasture, then mobile robots capable of milking grazing cows in the field, which are already in development in Europe, would lead us to single group herds and barns with “parking spaces” for mobile robots to milk inside in winter and on rainy days. In terms of the technology itself, if attendance for milking is feed driven, and part of the benefit of robotic milking is milking the cow closer to her living space with less impact on her time budget, will the next evolutionary step be robotic milking at the feed fence itself?

So while I am confident current barn design recommendations are getting close to ideal for current robot technology, there is little doubt that over the longer term further change and evolution is inevitable.

▪ References

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