Designing Automatic Milking Systems for Cow Comfort

Jack Rodenburg
DairyLogix Consulting
173 Falcon Drive
Woodstock, ON N4T 1W5
Tel: (519) 290-7194 Fax: (519) 290-7676
E-mail: jack@dairylogix.com
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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 fewer people to manage a much larger dairies. 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 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, and in the crossover between the resting and feeding areas in forced 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. Wider one way finger gates are also an asset in preventing bottle necks in crossovers in forced traffic barns.

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 about 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 can often mean there is only one person in the barn, 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 an option. 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 stalls are on the market now, but can be dusty and difficult in open windy barns. Belt feeders adapted for delivering bedding to the front of the stalls are also available and 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 on a farm in British Columbia. Gel Mats, 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. To minimize the time involved, layouts should offer straight lines through the barn with doors at each end. 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 tube 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.

Foot Bathing the Robotic Herd

Since hoof health is critical to success in robotic milking the strategic use of an effective foot bathing routine is essential. But it is also problematic. Footbaths placed in the exit lanes of the milking stalls can discourage cows from visiting the robot on foot bathing day. In larger herds with free traffic this could also involve a lot of labour caring for several footbaths for a full day at a time. Experts suggest a good footbath should be at least 10 feet long so cows take two full steps when passing through it. Since many barns have limited space at the robot exit it may be advisable to add a locking feature to the one way gate at the end of the lane, that releases the cow 5 to 10 seconds after she enters the footbath. Some cows, usually the ones with healthy feet visit the robot 7 or 8 times per day, and these cows will get many more passes than lame cows that need the bath but only show up twice when fetched. In a "tollgate" layout (see figure 4) it may be possible to use a selection gate to send only selected cows through the footbath to avoid the extra passes for the frequent visiting cow.

An alternative method of foot bathing is to build a large bath that is at least 10 feet long and the full width of a cross over at a point far from the robots. Ideally this should be a location where it can be used by all groups of cows in the barn. This bath should be hinged so that it can be stored vertically at the end of the row of free stalls and lowered and filled when needed. Once filled the entire group of cows can be walked through the bath slowly once or twice, before the bath is emptied and cleaned up. Although this does disturb the cows, there are many advantages. It keeps harsh chemicals like formaldehyde and copper sulfate far away from the milk and from the expensive robotic equipment. It increases the effectiveness of the chemicals since there is less exposure time to manure, and it results in a uniform number of passes for all cows in the group.

A third option for foot bathing is to place the footbath in a lane beside the robot exit as illustrated in Figure 3. In this system the post milking separation gate diverts cows that require foot bathing through the footbath after milking while cows that do not require it are returned directly to the group. In many cases the lane used for this will also be the separation lane, and in that case a second sort gate is needed to send foot bathed cows back to the main herd and separation cows to the separation area. As shown in Figure 3, a single footbath can serve two robots in this "L" layout by directing cows from the robot with no footbath, into the fetch pen of the other robot. These cows will be refused milking in the second robot and then sent through the foot bath.

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 and farmstead. Raising the office floor 2 to 3 feet 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 Forced Cow Traffic

Since the choice of forced vs. free traffic has a substantial impact on both labour efficiency and cow comfort it is an important decision in the design of AMS housing facilities. Since this appears to be a highly controversial topic at the farm level, a thorough referenced review of the literature is included here. Studies have shown that attendance, while no longer “voluntary” in the pure sense, can be improved by forcing the cow to enter the AMS stall or an associated selection gate en route from the resting area to the feed manger or on her return from the manger to the resting area. This is commonly referred to as “forced” cow traffic. There are at least four common variations of “cow traffic” strategies used in AMS herds today. (1) Free cow traffic, where cows can access feeding and resting areas of the barn with no restriction. (2) Forced cow traffic with one way gates blocking the route from the resting area to the feeding area so cows leaving the resting area must enter the milking box, to be milked if the interval since the last milking makes them eligible, or "refused" if the milking interval is too short. After passing through the milking stall, the cow is released to the feeding area and can only return to the resting area through a one-way gate. (3) Forced cow traffic with "pre-selection" adds an entry lane where a sort gate directs cows eligible for milking to the commitment pen and ineligible cows to the feeding area. This reduces waiting times for milking and for feed because only cows eligible for milking pass through the milking stall. Pre-selection can also be provided by selection gates in crossovers away from the robot, which open only for cows ineligible for milking. (4) Feed first forced traffic is a reversal of (2) which allows cows access to the manger from the resting area via one way gates, but they can only return to the resting area through the robotic milking stall, or through pre-selection gates that direct cows ineligible for milking directly to the free stalls or bedding pack.

Numerous studies report slightly higher milking frequency and a much-reduced need to fetch cows with forced traffic. (Hogeveen et. al., 1998; Van't Land et. al., 2000). (Harms et. al., 2002) reported 2.29, 2.63 and 2.56 milkings and 15.2, 3.8 and 4.3 fetching acts per day with 49 cows in free, forced and forced with pre-select traffic respectively. The number of meals was higher at 8.9 with free cow traffic, than with either forced or forced with pre-select, where cows consumed 6.6 and 7.4 meals respectively. Forage intake decreased when cows were switched to forced traffic and went back up in the forced with pre-select phase. (Hermans et. al. 2003) reported that cows with free access to forage in the manger spent more time eating and less time standing in free stalls. (Thune et. al., 2002) reported 1.98, 2.56 and 2.39 milkings, and 12.07, 3.86, and 6.46 feeding periods with free, forced and forced with pre-selection traffic respectively. In this study, dominant and timid cows spent an average of 78 and 95 minutes waiting for milking in a free traffic setting vs. 124 and 168 minutes with pre-selection and 140 and 240 minutes with forced traffic. Timid cows waited an average of 4 hours per day for milking because, they are directed into the commitment pen en route to or from the manger, but higher ranking cows continually beat them into the robot, leaving them trapped in the commitment pen for several hours. From a cow comfort perspective this is highly undesirable and may lead poor metabolic health and increased lameness, eventually leading to a further deterioration in visiting behaviour. On Ontario farms with forced cow traffic (Rodenburg and Wheeler, 2002), average number of daily visits per cow, and therefore visits to the manger to consume TMR was 3.40 + 0.44. This is many meals fewer than the 12.1 (Vasilatos, 1980) per day reported in a trial with free access and parlor milking. Fewer meals are associated with lower dry matter intake (Dado and Allan, 1994) and forced cow traffic has been shown to have this effect (Prescott et.al., 1998). Pre-selection systems result in some improvement in feed access but number of meals remains lower than with free traffic. Cows in forced traffic situation also spend more time waiting for milking and less time lying down, (Winter and Hillerton, 1995). It is also of some concern that when a cow is in pain from a clinical case of mastitis or when she is lame, she will avoid milking in a free traffic situation and this alerts the herdsman to her plight. Faced with the choice of starvation or milking this cow is more likely to go unnoticed in a forced traffic setting.

Stress responses as measured by heart rate, blood cortisol levels and stepping and kicking during milking have been thoroughly studied and reviewed (Jacobs and Siegford 2012). A full report of the findings of these studies is beyond the scope of this paper, but as a general summary, the bulk of the studies suggest that milking itself in an AMS involves similar or less stress than parlor milking. Some studies do suggest that in barns with forced cow traffic, cows experience slightly higher stress levels throughout the day. (Wenzel et.al. 2003, Hagen et.al. 2004, Albeni et.al. 2005). (Munksgaard et. al. 2011) reported no differences in any parameter measured between forced and free traffic with 34 cows per AMS, suggesting that when there is a lot of excess capacity available, cows can and do behave identically in both traffic systems.

In the most recent comprehensive comparison for the two traffic systems (Bach et. al., 2009), cows were fed a partial mixed ration and up to 6.6 lbs of concentrate in the milking stall. Results summarized in table 1, illustrate that milking behavior, eating behavior and milk composition were all influenced by the choice of traffic system, but total dry matter intake and milk production were similar.

Table 1: (Bach et. al. 2009) Feeding and milking behavior, and milk production and composition of cows with free vs. forced traffic.

(Per cow per day)	Free Traffic	Forced Traffic	SE	P-value
Total Milkings	2.2	2.5	0.04	<0.001
Fetched Milkings	0.5	0.1	0.03	<0.001
PMR* intake	41.0 lbs. (18.6 Kg)	38.8 lbs. (17.6 Kg)	1.34	0.24
No. of meals of PMR	10.1	6.6	0.30	<0.001
Concentrate Intake	5.5 lbs. (2.5 Kg)	5.5 lbs. (2.5 Kg)	0.09	0.99
Milk production	65.7 lbs (29.8 Kg)	68.1 lbs. (30.9 Kg)	1.74	0.32
Milk fat % (lbs.)	3.65 (2.40 lbs)	3.44 (2.34 lbs.)	0.078	0.06
Milk protein % (lbs.)	3.38 (2.22 lbs.)	3.31 (2.25 lbs.)	0.022	0.05

* a partial mixed ration formulated for 15.4 lbs (7 Kg) less milk than the average production of the group.

From a feeding standpoint forced traffic reduces the importance of providing a highly palatable feed in the AMS. Although it will still be advisable to feed 2 to 3 kg of concentrate per day in the AMS, perhaps a lower cost mash feed produced on the farm can be substituted for the commercial pellets because, as long as there is no alternative, most cows will go through the AMS out of sheer need to consume the ration at the feed manger. But reduced number of meals, reduced feed intake, reduced resting time, and longer waiting times, especially for timid cows make this system less desirable from the stand point of cow welfare and long term productivity.

With current technology there are numerous examples of robotic milking herds with free traffic that report over three milkings per day and very few fetch cows. (Rodenburg 2012) There are also numerous examples of forced traffic herds that report high feed intake, good production and few health issues. This demonstrates that both systems can work successfully under ideal circumstances. But when less than ideal conditions prevail, with free traffic the dairyman suffers the consequences in the form of fewer milkings and more fetch cows. With forced traffic the cows suffer the consequences with lower feed intake, and longer waiting times. Since problems are much more likely to be resolved quickly when the dairyman suffers, for this author, free cow traffic is the preferred management system.

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, forced 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 forced traffic milking stall.

Forced traffic barns should always strategically reduce the traffic from cows not eligible for milking in and around the robot, with at least a pre-selection gate at the entry to the holding area and one additional selection point per 60 cows, in a crossover away from the robot area.

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 with the system 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 as well as with tail to tail robots, routing that allows further milking visits for the separated cow can be challenging. Robot rooms housing a single robot generally allow 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 elevation of the floor in the robot room is somewhat a matter of preference. The cows will be most comfortable if the floor is at the same height as the milking platform. Add a 1 foot wide rubber strip in the room along the edge of the robot, to improve the footing of cows that step off the platform on this side. 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. Needling and treating cows in the robotic milking stall should be strongly discouraged, because this needs to be a happy place that the cow wants to come back to very often.

The Fetch Pen

With free traffic layouts a fetch pen or 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 commitment pens which all cows must access prior to milking create additional stress on low ranking cows who may spend long periods in the pen with no way to leave it except through the robot which is always busy milking more aggressive cows. 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 who 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 fetch pen. 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 fetch pen 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.

In traditional forced traffic barns with pre-selection cows eligible for milking are directed into a commitment pen, which they can only leave via the robot. The pre-selection gate already prevents these cows from going to the "other half" of the barn, there is no reason to also prevent them from having the freedom of the entire half they are restricted to. With strategic gating the commitment pen in these barns can be designed so it is only used when training a new animal.

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 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 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. Many advisors have come to the conclusion that the only viable option for handling in a robotic milking herds is to include headlocks throughout the barn. Headlocks do offer a very efficient way to perform specific tasks, especially singing udders to remove excess hair. Most robot herds do this 5 or 6 times per year to increase the cleanliness of the udders and accuracy laser teat location and attachment. But just like handling and treating cows in the parlor or robot is ill advised because this is not a good place for bad experiences, the manger should be a welcoming area that cows are happy to go to often to eat large amounts of feed. Except for flaming udders, handling cows in headlocks always involves restraining and stressing cows you don't need to handle unnecessarily.

Although experience with such systems is limited, barn designs that include a large separation area offer the option of not using headlocks in the main milking cow section of the barn. 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 robot access for additional milking. It also has to provide convenient access to a working chute before returning to their main housing areas. For activities like reproductive herd health, where it is cost effective to always have the next cow ready for the veterinarian it may even be beneficial to have two working chutes side by side, or alternatively it may be desirable to include a palpation rail beside the separation area for group handling cows for flaming udders or reproductive exams. 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 reproductive exams. This is probably the second most valuable use of the “second group option” It is tempting to revert back to headlocks for group handling in the separation area, but if cows do not see headlocks routinely in the milking barn, they may resist using the in this area that is already less familiar to them. If the separation area makes strategic use of flexible dry cow space along the manger, this area can provide room for very convenient headlocks, but if the presence of headlocks here discourages close u dry cows from eating it could have detrimental consequences. From the standpoint of cow comfort, for group handling in the separation area either two chutes side by side or a palpation rail are more desirable options than headlocks.

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. With the exception of the 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 more gradual if possible.

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 to 8 foot wide alley across at least one end 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.

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 where it is practical to do so. Back to back robots in the layout commonly described as a "tollgate" do exhibit reasonable cross use and can be a viable alternative that involves robots with opposite entry points. In a 4 robot barn using the "L" layout described later, using two left handed robots in one group and two rights in the other makes it easier to direct cows to a central handling area.

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. 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. In a two robot barn, perimeter feeding increases the ability to vary group size and choose between having two sixty cow groups accessing one robot each or one 120 cow group accessing both robots. Experience today seems to suggest that 120 cow groups of cows unselected for stage of lactation or age with access to two robots is the most practical approach to grouping.

Other Brands call for Different Layouts

With respect to barn layout, the requirements and possibilities with the long established Lely and DeLaval single box systems are identical. Other brands may make it easier or more difficult to apply these principles. BouMatic is now marketing a system in Europe and Canada that comes with the "robot room, included so no additional construction is required. Since cows are milked from the rear, their single box permits entry and exit on both sides, making separation and milking special needs groups much easier. From a cow comfort standpoint, the fact that special needs cows don't have to make a turn when leaving the robot is particularly beneficial since this group will include fresh and lame cows with impaired mobility. But the BouMatic double box, and double box Insentec systems that service two cows standing side by side, make separation more difficult. The tollgate layout Illustrated in figure 4 is one way to address this limitation. The GEA multibox offers a system in which one robot arm on a track services up to 4 stalls placed end to end. This configuration only permits access from different groups and separation for handling when a commitment pen is used, and this will have a cost in terms of waiting times and stress for timid cows. While this is less than ideal for cow comfort, with adequate open space around the selection gates and in the commitment pen this can work well as long as robot capacity limits are respected. For GEA owners that want free traffic it is possible to offer that, but without any capability for sorting or milking special groups

Minimizing Cow Comfort Issues in Forced Traffic Situations

Although forced traffic and commitment pens create additional stress on low ranking cows, there are ways to minimize the unnecessary waiting . The goal is to minimize waiting in the commitment pen, and avoid line ups at selection gates. Having multiple wide one way finger gates, and multiple selection gates with open space around them, where cows can cross from one side to the other will reduce bottlenecks. Using a separate fetch pen and giving cows waiting for the robot the option to move around freely on the side they are on would also reduce stress, and priority lanes for timid cows are also beneficial.

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 and Figure 3, 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, Denmark 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.

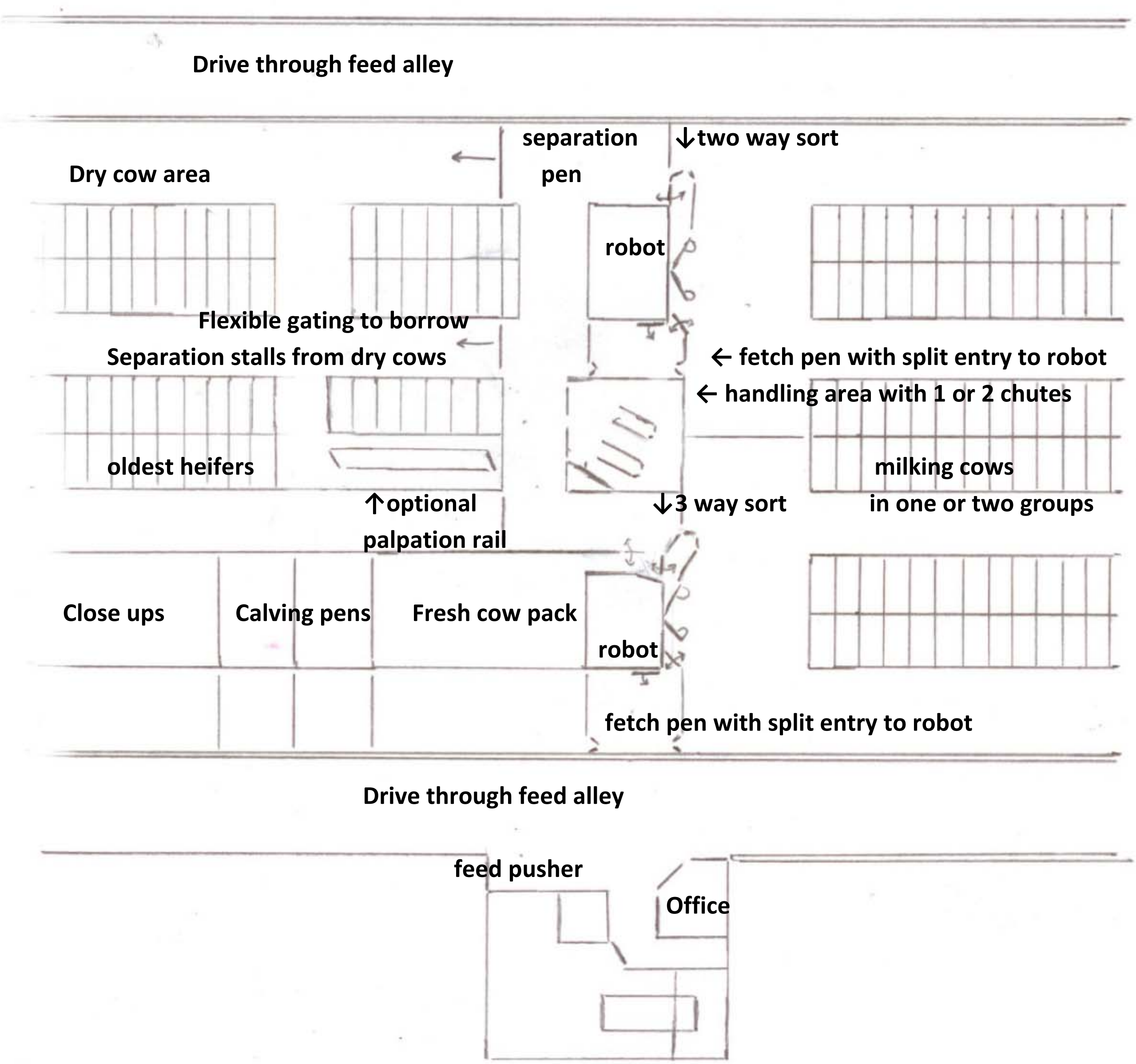

Figure 1. The robot and handling area of a 2 robot barn

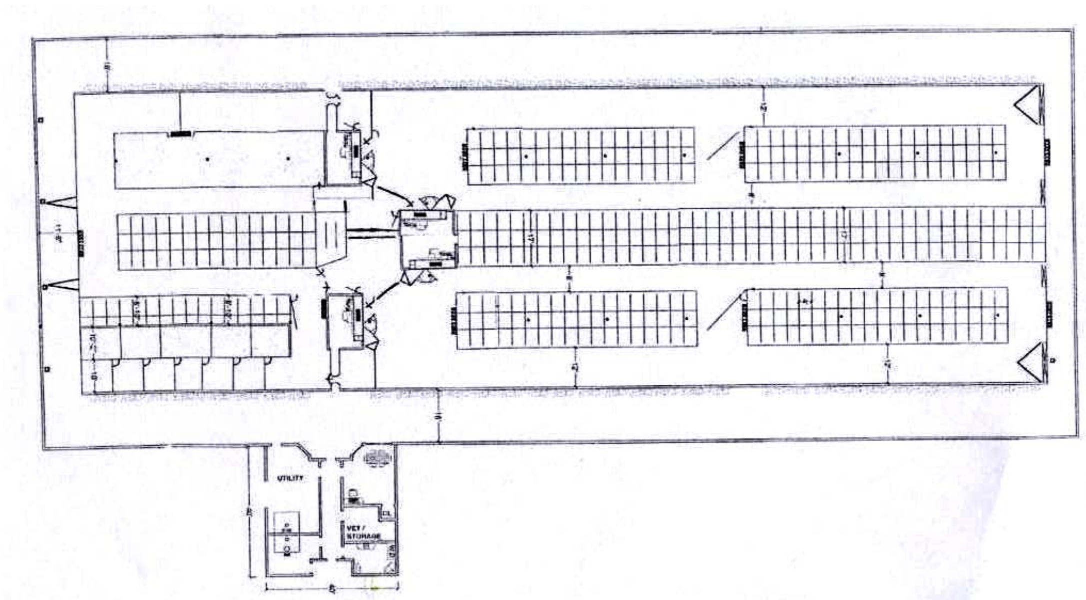

Figure 2. A 4 robot layout with handling and special needs on the left and two groups of 120 milking cows on the right.

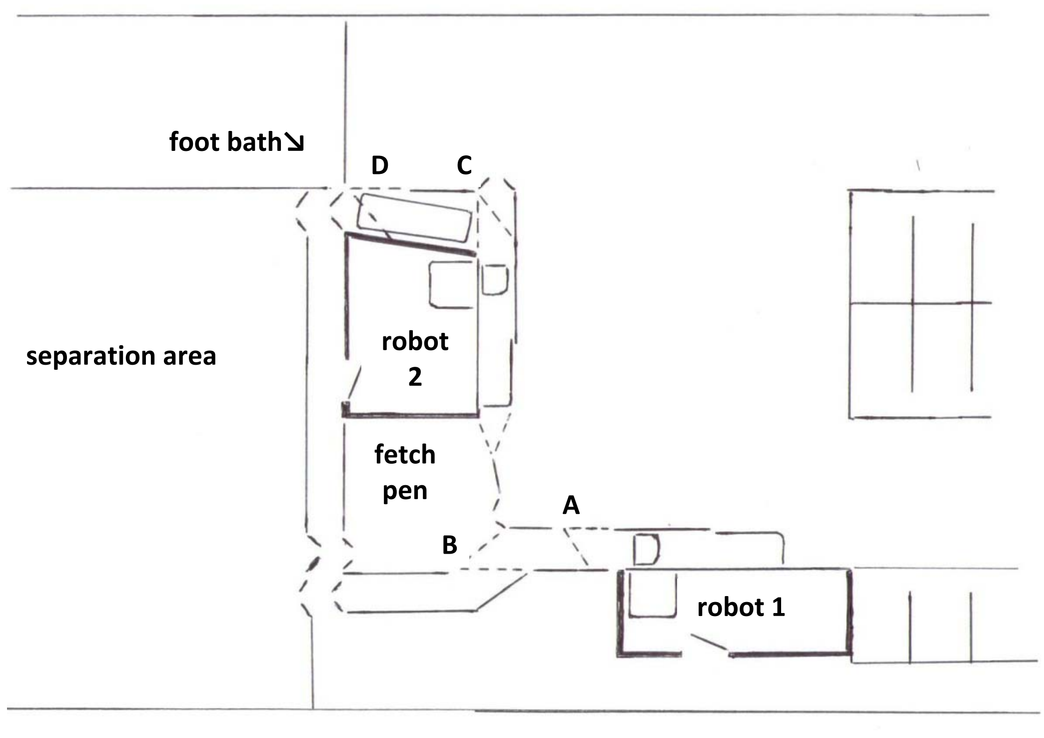

Figure 3. An illustration of two robots in one 120 cow group in an L formation. Cows from robot 1 can be separated through a lane below the fetch pen. Separated cows have access to robot 1 for milking. For foot bathing sort the cow from robot 1 into the fetch pen with gates A and B. After she is refused in robot 2 sort her left at gate C though the bath and right at gate D back to the herd.

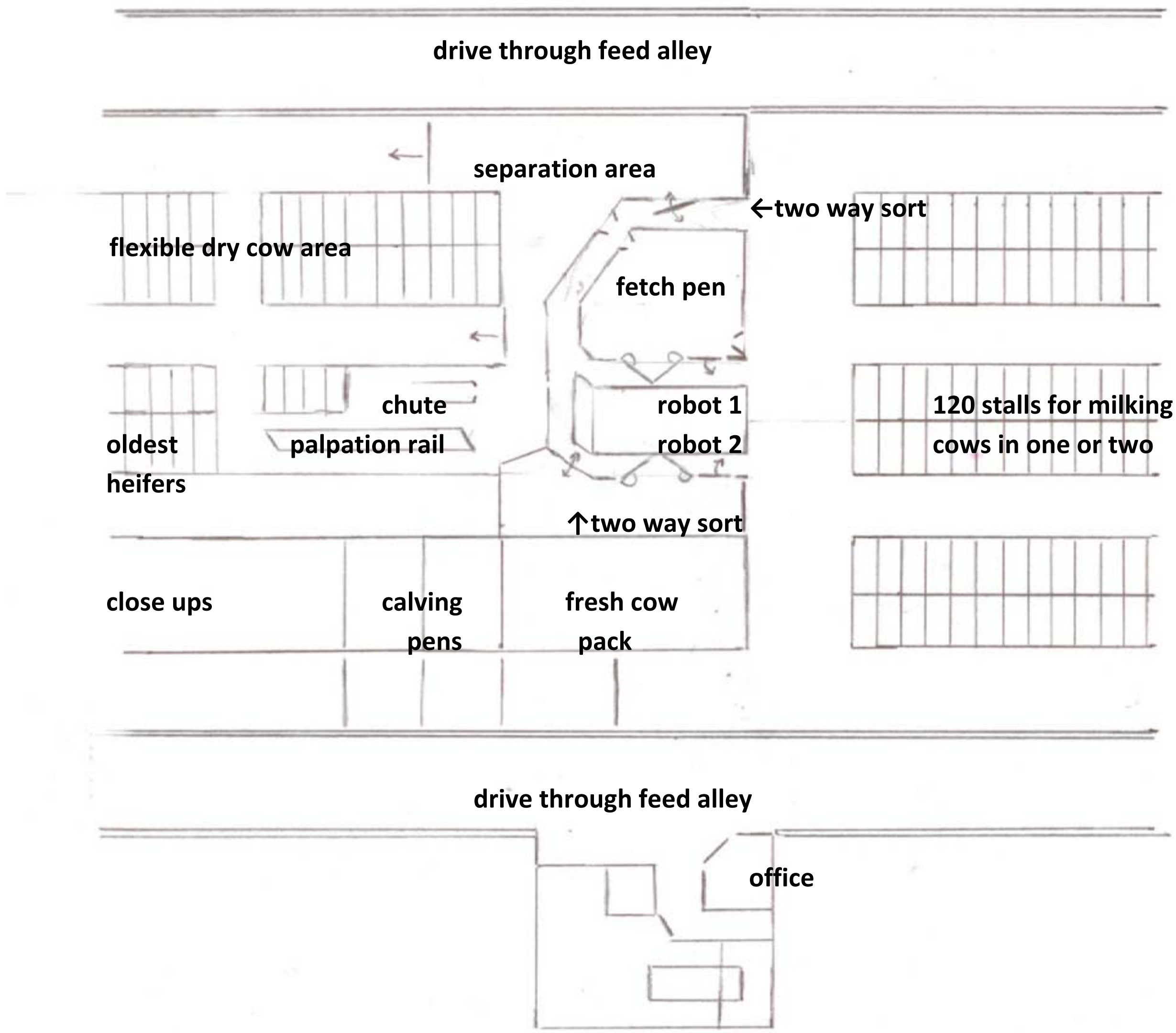

Figure 4. An illustration of two robots in a "tollgate layout"

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