SUCCESS FACTORS FOR AUTOMATIC MILKING

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Introduction

Automatic milking has gained widespread acceptance, particularly in western Europe, as a way to reduce labor requirements on dairy farms and improve the lifestyle of dairy farm families milking 40 to 400 cows. At the end of 2009, worldwide, an estimated 8000 commercial dairies used one or more automatic milking systems (AMS) to milk their cows (De Koning, 2010) and it is likely that this number is now well over 10,000. The first commercial robotic milking systems in North America were installed in Ontario, Canada in 1999, and there are close to 1000 farms, predominantly in Canada and the north eastern USA milking with robots today. Although the majority of installations are Lely and DeLaval single box systems, Boumatic Robotics, GEA Farm Technologies, and Insentec also have AMS operating on commercial farms in North America today.

Widespread adoption of this technology suggests at least a measure of success in helping dairy farmers achieve greater labor efficiency and a better lifestyle. But field experience, also suggests that there is wide variation in the amount of labor saved and in the overall satisfaction of early North American adopters. There is a substantial body of research to guide us in the management of this technology. Two excellent reviews summarizing the impact of automatic milking on udder health (Hovinen and Pyoralia, 2011) and on cow management, behaviour, health and welfare (Jacobs and Siegford, 2012b) have been published recently. But there is also much to be learned from practical experience in the field. This paper offers a practical overview of success factors contributing to labour efficiency, cow comfort and productivity in AMS herds, with support from research when relevant studies have been published. As a relatively new way of milking cows, this technology continues to improve, and has undergone substantial evolution in the last ten years. Both the technology available today and the management and facilities producers place around it, are more reliable, more cow friendly and more efficient than many of the systems on which data was collected and reported, in formal research projects. As a result much of the historical data in the literature is of limited value in defining the automatic milking experiences of farms who adopt this technology today.

Defining Success with AMS

In practical terms no discussion of the factors contributing to success can begin without an understanding of what objectives define success for the producers choosing AMS. Improving profitability should be the major driving force for adopting new technology. In a study of Dutch farms investing in either new AMS or a new parlor, (Bijl et. al. 2007) reported that money available for rent, depreciation, interest, labor and profit, was greater "per farm" on conventional dairies by €15,566 but was greater "per full time employee" by €12,953 per year on AMS farms.

Labor on AMS farms was 29% less. Labor saving is also an important objective of AMS, but as with profitability, accurate comparable data is not readily available. The success of automatic milking is dependent on the cow and her willingness to visit the automatic milking stall voluntarily with sufficient frequency to support an economic level of milk production. Since the milking herd never leaves the barn, stall maintenance, manure removal, and cattle handling require a different approach than with conventional milking. Capitalizing on the opportunities for labor saving hinges on the ability of AMS farms to achieve frequent voluntary milking and on minimizing the work of cattle handling. The health and comfort of the cow is a major factor in visiting behaviour, making it critical to the success of automatic milking.

Since data on profitability and labor saving are difficult to come by, the more common measures of success for comparing the performance of AMS are such factors as milk production per AMS unit, and milk production per cow. There is very little comprehensive published data on average production per AMS but for single box systems 4400 lbs per day, from 60 cows producing 73 lbs per day is often quoted as a reasonable goal. A study of 34 herds in Spain (Castro et. al. 2012) reported average production of 3320 lbs per day from 52.7 cows producing 63 lbs per cow. At the extreme of efficiency, DeLaval (Healey, 2013) recently issued a press release recognizing JTP Farms in Wisconsin for recording a one week average daily production of 6453 lbs of milk per VMS for 4 VMS units milking an average of 62 cows yielding 104.5 lbs of milk. Similarly Lely has several herds in Spain, Italy, USA and Canada over 6000 lbs per stall and over 90 lbs of milk per cow.

Another measure of AMS success that is closely monitored by owners is the average milking frequency per cow. Because this average includes a wide range of results from individual cows, this value, typically ranging from 2.2 to 3.2 is in no way comparable to 2x or 3x fixed interval milking. it is well understood and accepted that more frequent milking stimulates higher milk production, but large variation in milking interval decreases milk yield, (Bach and Busto, 2005). The goal in AMS should be both frequent milking and uniform milking intervals. In one trial (Melin et. al. 2005), cows with milking permission every 4 hours were milked 3.2 times daily while cows with milking permission every 8 hours were milked 2.1 times daily and produced 9% less milk. Based on field experience herds switching from 2x timed milking to AMS need to achieve at least 2.3 to 2.4 milkings per cow per day to match their previous production. Since more frequent robotic milking also means more regular milking intervals 3.1 to 3.2 milkings per cow per day will come close to matching 3x timed milking.

One of the new labor demands in AMS systems is fetching cows that do not attend voluntarily. Fetching one or two cows per AMS generally requires minimal effort and in barns with logical cow routing and gating it can be combined with cleaning the freestalls. Fetching larger numbers requires labor and also disrupts the voluntary traffic to the AMS. In a Canadian survey producers reported fetching 4 to 25% of cows and the variation between herds was large. (Rodenburg and House, 2007). Minimizing the number of cows to be fetched while maintaining a high level of cow comfort, health and productivity is a criteria for successful automatic milking.

Impact of Stocking Rate

Since 2010, quota policies in Ontario have made it very difficult to expand and as a result there are a growing number of automatic milking farms with a lower number of cows per milking stall. In one recent study (Deming et.al. 2013) the number of cows per milking stall ranged from 34 to 71 among 13 herds in a field study. Higher stocking densities were associated with fewer milkings. While production per cow was unaffected in this trial, less frequent milking is typically associated with lower production (Melin et.al. 2005). An earlier field study (Rodenburg 2002) reported that the number of cows fetched because of long milking intervals increased when the number of cows per milking stall exceeded 60 and the liters of milk per stall exceeded 1500 liters. While newer AMS may have a higher capacity today, field observations suggest that systems that are under capacity experience more visits and milkings per cow, higher production per cow and fewer fetch cows. More research is needed to quantify the impact of higher numbers of cows, or more accurately, higher occupation rate (OR), defined as the percentage of the day the AMS is actually milking. Historically farmers and manufacturers have put a lot of emphasis on the production per AMS. When the capital cost of the system and interest rates are high, this is logical. In recent years, interest rates have been lower and the capital cost of AMS is declining. High production per cow has traditionally been associated with higher income over feed costs and higher returns to labor. With both feed costs and labor costs on the rise, perhaps a greater emphasis on production per cow and per unit of labor and lesser emphasis on production per AMS unit is appropriate today.

Selecting and Managing the Cows

Cows with higher milking speed will permit more cows and more milk production per AMS at the same occupation rate. Producers using AMS now or considering it for the future would increase the capacity of their system by selecting cows with a higher milking speed. If the average "machine on time" can be reduced by 1 minute per cow, the capacity of a milking stall can be increased by roughly 12%. Cows with poor udder conformation experience slower attachment and higher incidence of attachment failure and are twice as likely to require fetching (Jacobs and Siegfried 2012a) so selecting for udder conformation is also important. Although information on the genetic predisposition of cows to attend for voluntary milking is currently not recorded or published, a heritability ranging from of 0.16 when measured in early lactation to 0.22 measured in late lactation has been reported. (Konig et. al. 2006). With the growing popularity of robotic milking, individual cow milking frequency data should be collected by milk recording agencies and included in sire proving schemes.

Studies have identified a relationship between lameness and decreased AMS visits and higher fetch rates (Bach et. al. 2007, Borderas et.al 2008). Lameness is a multi-factorial problem influenced by nutrition, cleanliness of the barn, resting behaviour, preventative and corrective treatment and a multitude of other factors including the cow herself. Maintaining excellent claw health should be a priority for AMS farms.

Feeding Management and Nutrition

If AMS owners in Canada are asked for their opinion on what factors influence voluntary milking frequency and fetch rates, the majority would rank the feeding program as their first and foremost concern. Feeding research related to AMS has been reviewed (Rodenburg, 2011) Feed, is the primary motivation for the cow to visit the robotic milking stall. Highly motivated cows will visit voluntarily thereby decreasing the need to expend labour fetching cows, and they will visit more frequently and regularly leading to higher milk production. Forced cow traffic makes it possible to use forage at the bunk to provide motivation. Research findings and merits of various traffic systems are discussed later in this paper. With free cow traffic, motivation to visit the robot is provided solely by the concentrate fed in the milking box. Hard, dust free pellets (Rodenburg et.al. 2004) made of palatable ingredients such as barley and oats (Madsen et. al., 2010) fed at a rate of 5 to 17 lbs per day result in the highest visit frequency and highest milk production. Limiting the energy density and starch level in the mixed ration fed at the bunk also increases the motivation provided by the concentrate (Rodenburg and Wheeler, 2002) Current recommendations suggest feeding a partial mixed ration formulated for a production level 15 lbs below the mean of the group, combined with 5 to 17 lbs. of pelleted concentrate fed according to production in the robotic milking stall. While the need to use feed to stimulate milking visits creates additional challenges for the nutritionist and feed advisor, the ability to collect a great deal of data on the individual cow and to feed and supplement her individually also creates many new opportunities for more precise and individualized ration delivery.

Forced vs. Free 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 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 holding area 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. (Hoogeveen 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 freestalls. (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 fetch pen en route to or from the manger, but higher ranking cows continually beat them into the robot, leaving them trapped in the fetch 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 2012b). 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 %	3.65	3.44	0.078	0.06
Milk protein %	3.38	3.31	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.

Barn Design Concepts for AMS

AMS 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. There is very little published research defining what is ideal in a robotic milking barn, so this part of the paper will rely heavily on field experience.

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 forced traffic layouts. By placing a few one way gates in a heifer barn will train animals to use them before they calve. An “exit lane” one cow length long with a one way gate at the end, reduces the frequency of delayed exit by timid cows (Jacobs et. al. 2012) 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.

The design of an AMS 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 an AMS 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 must be set up to be a one person job. Moving through the barn with equipment to scrape manure or bring in bedding is 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 choice. Gel Mats, waterbeds or mattresses that require minimal bedding are recommended. Use of sand bedding will require large equipment, so to minimize the time and disruption involved, layouts should offer straight lines through the barn with doors at each end. Free cow traffic, wide alleys and multiple crossovers that provide escape routes for cows when equipment passes through are recommended.

Ensuring the area around the AMS is free of stray voltage by slatting it, or by including an equipotential plane in the concrete is recommended. Ceiling fans over the cow in the AMS help to cool cows 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 AMS 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. Since hoof health is critical to success in robotic milking the strategic use of an effective foot bathing routine is essential. Footbaths placed in the exit lanes of the milking stalls can discourage cows from visiting the AMS. 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 extra passes for the frequent visiting cow. An alternative method of foot bathing uses a large bath that is 10 feet long and the full width of a cross over furthest from the AMS, ideally in a location that can be used by all the groups in the barn. A hinged bath can be stored vertically at the end of the row of freestalls and lowered and filled when needed. Once filled, groups of cows are walked through the bath slowly once or twice in a row, once or twice a week. Although this does disturb the cows, it keeps harsh chemicals away from the milk and from the AMS. With less manure exposure, chemical work better and there is a uniform number of passes per cow. Routing for fetching cows should be simple and logical, so that this task can be combined with cleaning freestalls. Gates at the AMS 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. Many popular barn layouts feature robot rooms that include more than one AMS. While this is convenient for cleaning and servicing, air and vacuum leaks and straining bearings and joints are harder to hear than with one AMS per room. Accessing an AMS from more than one barn area and post milking separation are more difficult with more than one AMS per room. Back to back robots on a single room are common with the mirrored two stall Insentec AMS and with the Boumatic Robotics double box. 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.

With free traffic layouts a fetch pen for fetched cows is required. An area of 80 to 100 square feet suitable for 4 or 5 cows is recommended for use with a single robot. The fetch pen should not have access to water, feed or freestalls. Gating is required to direct fetched cows into it with no escape routes. A permanent commitment pens which all cows must access prior to milking create additional stress on low ranking cows. A temporary fetch pen is better, but the best option for holding and training fetched cows in a free traffic barn is the "split entry fetch pen" pioneered by DairyLogix. As shown in Figure 1 the fetch pen is used only for fetched cows who access the AMS via a lane beside the milking stall. Cows from the main barn still access the robot 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 AMS 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 AMS opens to her first. With this stepwise training approach, the heifer will move to voluntary attendance quickly. 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. 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, close to the AMS with voluntary access. Many of the cows will not go on their own, but fetching them from this pen involves minimal time and walking distance. This is the first and most valuable use of the “second group”.

Handling cows in an AMS herd for breeding, pregnancy checking, vaccinations, treatment, clipping, hoof care, flaming udders 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 an AMS herd, milking times cannot be predicted, so sorting at the AMS will require up to 15 hours of lead time. Hence a good sort pen must provide feed, water, a place to rest, and the opportunity to return for additional milking. Headlocks for robot barns are problematic because many cows are not interested in going to the manger when fresh feed is delivered. Many AMS 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 AMS management is poorly defined, in terms of what handling system minimizes operator labour and stress on the cows. Headlocks do offer a very efficient way to perform specific tasks, especially singing udders, which most AMS herds do 5 or 6 times per year to increase udder cleanliness and attachment success rate. Handling and treating cows in the parlor or robot has long been discouraged because it gives cows a bad experience in what should be a goof place. Although I have no research evidence for this handling in headlocks could also add stress to the feeding experience. Since headlocks restrain many cows that are not needed for handling, these cows are stressed unnecessarily. Barn designs that include a large separation area offer the option of not using headlocks. Convenient access to a working chute, or two chutes side by side, or a palpation rail located near the separation area is an alternative. If dry cows are housed behind the AMS a flexible gating can provide a lot of dry cow space and a small separation area 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. Separation cows are a second 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. In a barn with three or more robots in individual rooms surrounding a central handling area, all three applications can be included. Access by several groups to a central handling facility is easiest if cows do not have to cross a feed alley. Hence AMS barns work best with perimeter feeding, which also keeps rain, sun and frost out of the cow areas further enhancing cow comfort. A 6 to 8 foot wide alley across at least one of the barn permits crossing over inside the barn to push up feed.

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 on a dairy are oriented the same way if 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 easy to direct cows to a central handling area.

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 clear answers on what is ideal. Some herds opt for early and late lactation groups, or first and later lactation groups, but most 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. 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. Flexible layouts that permit variation in grouping strategies is ideal since there are no clear answers to which strategy is best.

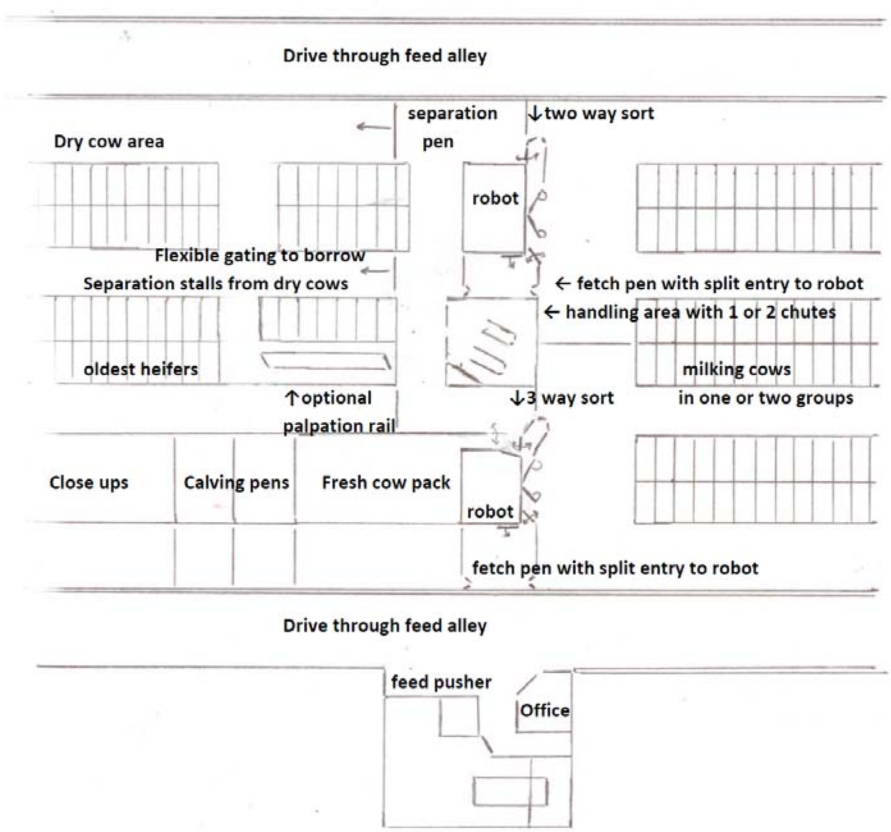

Fig. 1. A six row two AMS free traffic barn with perimeter feeding, a fresh cow pack and logical separation area.

Figure 1 presents a free traffic barn layout that includes many of the capabilities discussed above. In order to illustrate the 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 USA, 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.

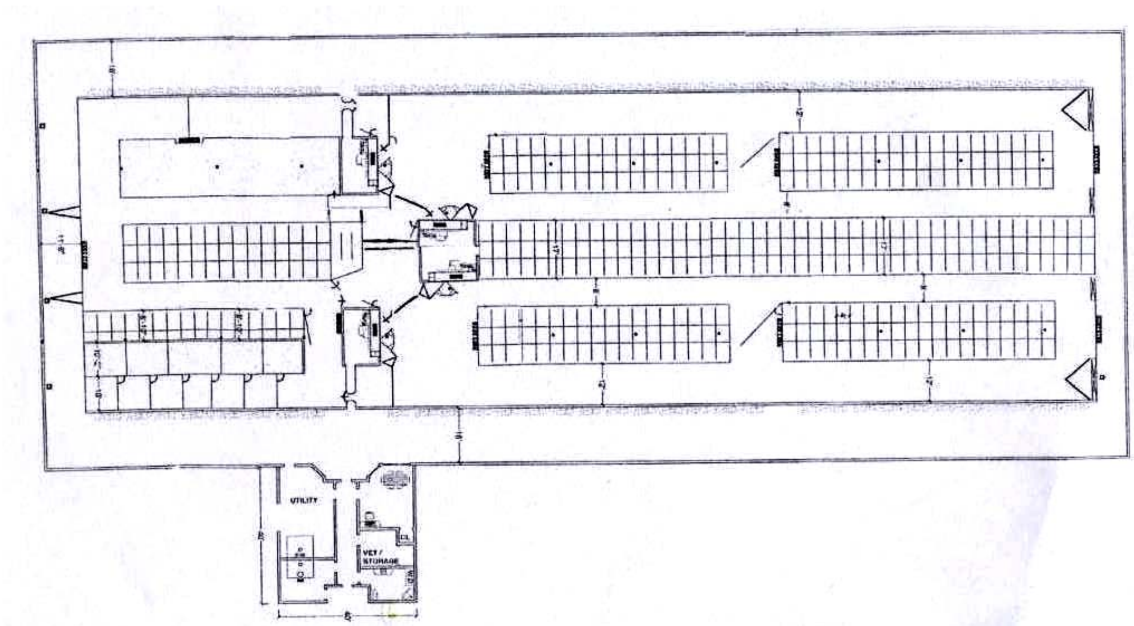

Figure 2. A 4 AMS layout with handling and special needs on the left and two groups of 120 milking cows on the right.

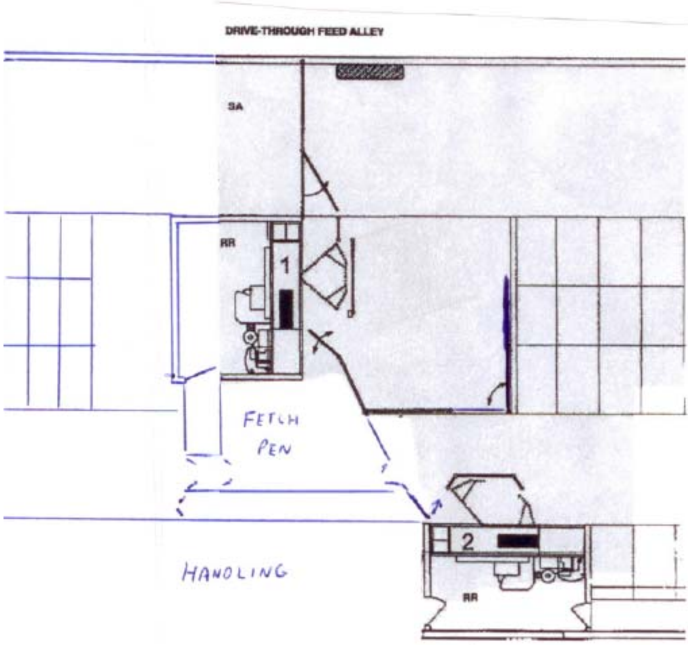

Figure 3. An illustration of two robots in one 120 cow group in an L formation. Cows from robot 2 can be separated through a lane or through the fetch pen and robot 1. Separated cows have access to robot 1 for milking.

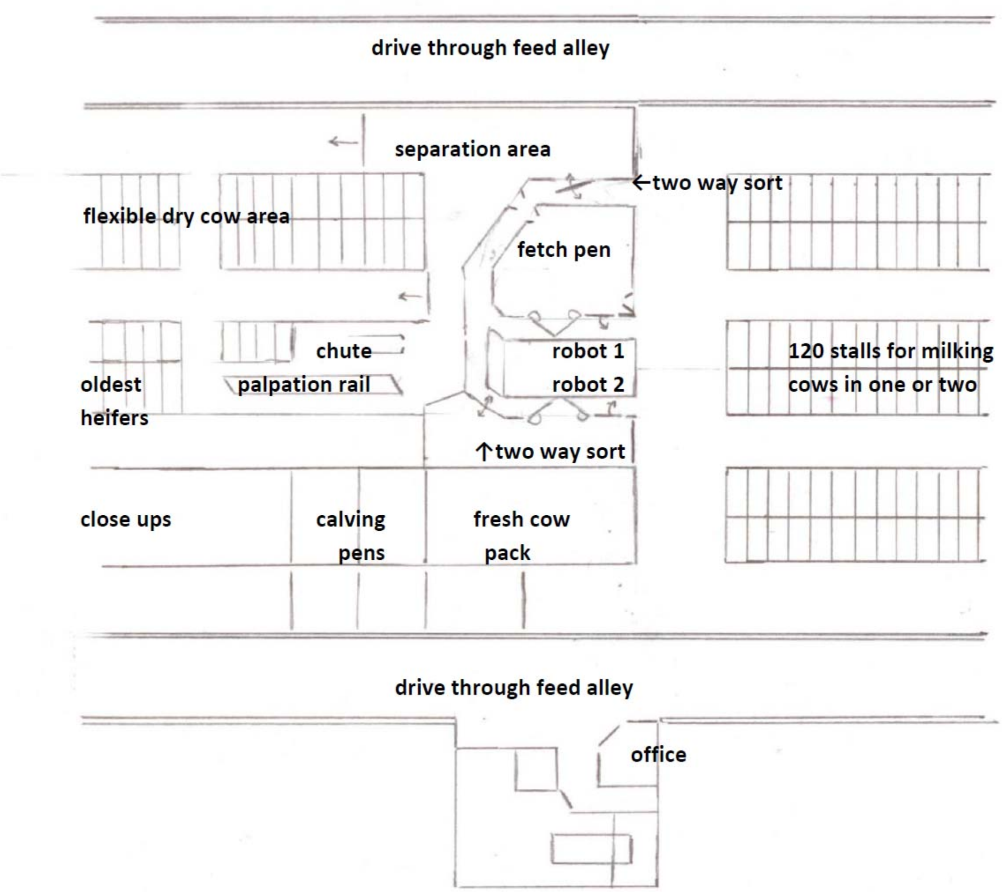

Figure 4. An illustration of two robots in a "tollgate layout"

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