# AUTOMATIC MILKING IS HERE…… SO IS IT TIME TO GET OUT OF THE SHED?

**Jenny Jago, Rodger Jensen, DairyNZ, Hamilton**

**Paul Berdell, Farmer Manager, Stradbroke Dairy, Winslow Ltd, Ashburton**

**Timeline of automatic milking system[1] (AMS) development**

| | |
|---|---|
| ~1985 | First milking cup is attached to a cow using a robotic arm under experimental setting |
| 1992 | First commercial AMS installed on a farm in The Netherlands |
| 2000 | Approximately 800 farms worldwide using AMS |
| 2001 | First cow milked in New Zealand using an AMS (Greenfield Project, Hamilton) |
| 2003 | Greenfield Project herd is expanded to 180 cows milked by two AMS |
| 2007 | Approximately 8000 AMS units in operation on farms in 22 countries worldwide |
| 2008 | First commercial AMS farms established in New Zealand |

## Introduction

At the SIDE conference in 2002 a paper was presented entitled "Robotic Milking – Fact or Fantasy[1]?" (Woolford and Jago, 2002). It is fair to say that at that time most farmers felt that the concept of cows being milked without people present resided fairly and squarely in the realms of fantasy. In 2008 the first two New Zealand commercial farms to adopt automated milking will begin operation. So what has changed in the past 6 years to allow this to happen and how has robotic milking moved from fantasy to fact?

There have been significant events in a number of key areas involving research outcomes, AMS equipment suppliers, the labour market and farmers attitudes to advanced automation technology:

- Research has shown that the fundamental principles of profitable pastoral farming (i.e. high pasture utilisation and low levels of imported feed) can be maintained with automatic milking.
- Research has also shown that the cows are willing and able to do their part to make extensive pastoral voluntary milking systems work.

[1] *An Automatic Milking System (AMS) refers to a system that automates all the functions of the milking process and cow management currently undertaken in conventional milking by a mix of manual and machine systems. They are often referred to as robotic or voluntary milking systems.*

- Major international suppliers of AMS view New Zealand as a significant long-term market
- National and international labour pressures have intensified

This paper describes the development of two farms that are using automated milking systems to milk their herds. One is a DairyNZ research farm in Hamilton that has been in operation since 2001 and has pioneered the use of AMS in low input pastoral farming systems. The second is a new commercial operation near Ashburton that will commence milking in August 2008.

## The Greenfield Farm, Hamilton

The Greenfield project was established in 2001 to test the viability of AMS within the New Zealand pastoral system and initially milked 40 cows on a small prototype farmlet with a single imported AMS (Jago et al., 2002). The farm has progressively developed over the past 7 years as knowledge of the key factors for successful automatic milking in a pastoral farming system has increased. Today the farm is 53ha of effective grazing land and in the 2007/08 season milked 180 mixed age cows using two Fullwood AMS. Heifers are grazed off the property.

**Greenfield Farm Profile, 2007/08 season**

| | |
|---|---|
| Land area | 53ha effective milking platform |
| Cows | 180 mixed breed, mixed age |
| Calving Pattern | Seasonal (planned start of calving 1 July, 10 weeks) |
| Staff | 1.5 FTE |
| Hours of work | 7am – 5pm, on-call out of work hours duties shared among staff |
| Farming System | 97.5% feed grown on farm, 2.5% imported feed, heifers grazed off |
| Farm Layout Features | • Flat contour<br>• Farm divided into two major blocks then further divided into three grazing areas with no internal fencing;<br>• Four remote selection units (two solar powered) that draft cows three ways according to readiness for milking, allocation of new pasture, queue status for cows waiting to be milked and individual cow behavioural patterns (i.e. infrequent or frequent visitor to selection units); |

| | |
|---|---|
| | • Water located at each selection unit and dairy;<br>• Central race with feeder race designs including a combination of one-way and two-way raceways;<br>• Temporary fencing used to allocate pasture breaks. |
| Dairy Features | • Two Fullwood (UK) Merlin automatic milking systems (AMS) commissioned in 2001 and 2003, major upgrade to teat detection system in 2007;<br>• Ability to manage two herds independently (e.g. colostrum cows have access to a dedicated AMS);<br>• Separation yards opening to pasture area for health alert, AI or failed attachment cows;<br>• Milk automatically diverted three ways (colostrum, antibiotic, supply);<br>• Cows separated for attention automatically, based on in-line electrical conductivity and SCC sensor data;<br>• Two feed heads and silos, buffer vat and main silo. |
| Technical Support | Routine maintenance and 24 hour technical on-call support contracted to local electrical firm, in-house trained staff available for high level technical issues. |

*Herd*

The herd is mainly Friesian and Friesian/Jersey crossbred cows that have been sourced from other DairyNZ research farms. They have not been specifically selected for automatic milking although any cows with unsuitable udder conformation and teat placement have been culled. The current herd has an average $BW of 116 (range $BW-48 to $BW205), and while there were less heifers entering the herd in 2007 (Table 1) compared to the national average there were also fewer 5 year olds. Milk production gains from fewer heifers were off set by less 5 year olds (milk production/cow peaks at 5 years old).

**Table 1**: Greenfield herd age distribution compared to national average

| Age | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ |
|---|---|---|---|---|---|---|---|---|---|
| Birth Year | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 |
| % National herd | 18 | 16 | 15 | 13 | 10 | 8 | 7 | 5 | 7 |
| % Greenfield herd | 12 | 22 | 19 | 5 | 9 | 7 | 9 | 8 | 9 |

*Farm Layout*

The current farm layout is shown in Figure 1. The farm is managed as two main blocks (one west and south of the dairy and the other north and east of the dairy) with cows grazing one of these main blocks at a time. Until 2007/08, only 45 ha could be used by milking cows, with the remainder (8 ha) used for dry cow grazing and silage conservation. The farm was very uniform in shape and did not present too many challenges for cows in finding their way to the dairy. In 2007/08 modifications increased the milking area to 53 ha presenting a more challenging layout for the herd. The farm is now less symmetrical, has various layout configurations and a maximum walking distance from the paddock to the dairy of 1km, providing a greater opportunity to learn about the pros and cons of a range of farm layout designs.

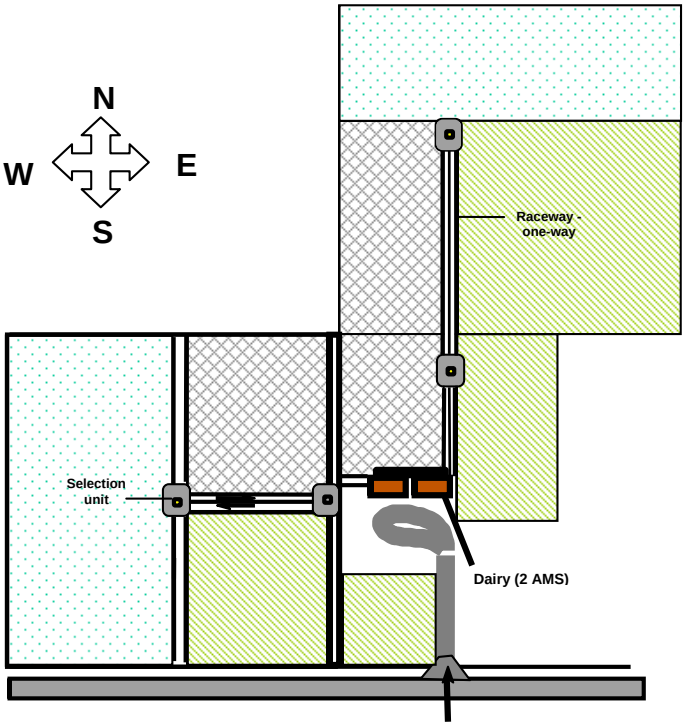


**Figure 1**: The Greenfield Farm layout including location of the dairy housing two AMS, and 4 remote selection units. The different shaded areas indicate the three grazing allocations per 24h (available from 8am, 2pm and 11pm automatically through the remote selection units) as described below.

At this farm the on-farm traffic control system is important for successful automatic milking. There are 4 selection units located at key points in the raceways, which consist of a small yard, water troughs and a set of computer controlled 3-way drafting gates. Cows typically visit the selection units 2-3 times throughout the day and night (range: 1 – 6+), motivated by the prospect of a fresh break of pasture or water. When due for milking (as determined by pre-set milking intervals and/or last-milking yield), individual cows are directed toward the dairy through a series of one-way gates, then return to pasture. Cows that

are not due for milking return to the same paddock, or are directed to a fresh break, if available.

*Feeding*

Feed supply comprises approximately 16.2 t DM/ha grown on the farm, with imported feed (0.45 t DM/ha ~ 20 t DM/year) kept to a minimum (2.5% of diet). The supplement (500g/cow/day) is fed at the AMS unit and doubles as an incentive to enter the milking crate without delay. Using the definitions of Hedley *et al*. (2006), which are based on the level of feed imported, the Greenfield Farm operates between systems 1 & 2 (system 1, no imported feed, 352 kg MS/cow; system 2, 5.5% imported feed, 360 kg MS/cow). Nitrogen fertilizer is applied at 200 kg N/ha.

*Grazing management*

Prior to 2007/08 a 12 hour grazing system was operated in which a new area of feed was made available approximately every 12 hours. Experience has shown that the timing of availability of fresh areas of pasture to cows is important when aiming for high AMS utilisation and consistent milkings throughout 24h. In 2007/08 a new system was put in place in which cows were offered three new areas of pasture each 24h, typically at 8am, 2pm and 11pm, automatically via gate changes at the selection units. This was one of the significant changes that lead to much improved performance for the farm compared to previous years.

Intakes of grazed pasture are affected by herd size, grazing area, pre-graze mass and duration of grazing period. Within a voluntary system cows are milked over a 24-hour period and the feed availability is a prime motivator of cow movement. Pasture residual mass is a critical factor to motivate the cows to move. Voluntary cow movement is necessary to obtain a desired milking frequency, which affects milk yield. The effect is a cyclic pattern of linked events that will determine productivity of the system (Figure 2.)

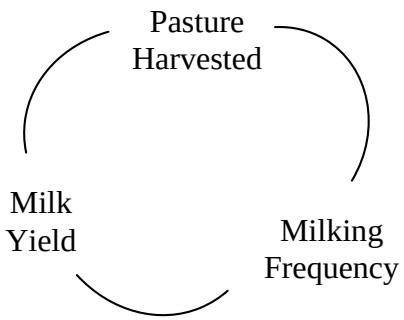


**Figure 2.** Cyclic pattern of pasture harvested, milking frequency, and milk yield within an automatic pastoral farming system.

Experience has shown that as pasture residual levels increase the cows will reduce voluntary movement and therefore milk less frequently with the flow on affect in reduced yield. This creates a reduced feed demand, which in turn will result in higher residual mass level. The direction of this cycle is critical for pastoral AMS. To attain a positive impact on production the feed allocation/presentation needs to be designed with cow movement in mind. Distributing a daily pasture allocation into three breaks reduces the occurrence of milked cows being directed to a break with a residual mass, and increased cow trafficking during the 2am – 7am period. Proportionally feed is allocated to induce movement post midnight. Within the 24 hours the daily allocation is proportioned as: 8am-4pm 37.5 %, 4pm – 11pm 25 %, 11pm – 8am 37.5 %.

*AMS utilisation and milking frequency*

The utilisation rate for the two AMS is an important focus for the Greenfield farm. Prior to 2007/08 peak utilisation rates of approximately 60% have been observed, with low use of the machines after about 2am until dawn. The data in Tables 2 and 3 shows that in the 2007/08 season milking frequency and AMS utilisation between midnight and 7am both increased when compared to the 2006/07 season. AMS utilisation peaked at 70% in September. The flow on effects on milk production can also be seen in Table 2.

**Table 2:** Herd average milking frequency, interval, and milk production for 2006/07 and 2007/08 for the months of July through January.

| | Milkings/cow/day | | Milking interval (hours) | | Milk production (kg/cow/day) | | kg MS/cow/day | |
|---|---|---|---|---|---|---|---|---|
| | 06/07 | 07/08 | 06/07 | 2007/08 | 06/07 | 07/08 | 06/07 | 07/08 |
| July | 1.8 | 1.8 | 13.5 | 13.0 | 17.7 | 18.0 | 1.44 | 1.63 |
| August | 1.38 | 1.5 | 18.6 | 15.6 | 15.9 | 20.0 | 1.34 | 1.72 |
| September | 1.2 | 1.3 | 19.7 | 19.0 | 17.4 | 19.8 | 1.46 | 1.63 |
| October | 1.3 | 1.4 | 19.1 | 17.4 | 16.4 | 19.0 | 1.35 | 1.55 |
| November | 1.2 | 1.4 | 19.8 | 17.2 | 15.3 | 19.0 | 1.29 | 1.55 |
| December | 1.3 | 1.5 | 19.2 | 15.9 | 14.6 | 17.6 | 1.26 | 1.43 |
| January | 1.4 | 1.4 | 19.4 | 17.4 | 12.9 | 14.0 | 1.12 | 1.14 |

One change that contributed to this improvement early in the season was modifications to the waiting yard configuration that allowed a separate colostrum herd to be managed with a dedicated robot. Operationally this was very successful as a rinse (~8minutes) was not necessary following each colostrum cow milking, saving considerable time and

allowing more machine time for milking. A second significant change that is believed to have had a positive impact on AMS utilisation and milkings after midnight is the introduction of the three break grazing regime discussed earlier.

**Table 3: A**verage number of cows milked between 12am and 7am, robot utilisation rate (%) in parenthesises.

| | 2006-07 | 2007-08 |
|---|---|---|
| July | 9 (21) | 17 (27) |
| August | 26 (50) | 43 (58) |
| September | 45 (59) | 50 (70) |
| October | 35 (57) | 56 (63) |
| November | 32 (54) | 60 (61) |
| December | 38 (57) | 62 (61) |
| January[1] | 35 (53) | 42 (53) |

[1]The lower utilisation in this month was a result of shifting the herd to a once a day milking regime due to a feed supply deficit that occurred in this month.

*Pasture harvested*

Pasture harvested is an important indicator of profitable dairy systems and in the past achieving high levels equivalent to best practice dairy farms has been a challenge on the Greenfield Farm. Table 4 shows the estimated pasture harvested for the Greenfield Farm from 1 June 07 through 31 January 08 and for the equivalent period of the 2006/07 season. This period has been chosen for comparison as the post January period was affected by severe drought in the Waikato region making comparison with previous years difficult.

**Table 4:** Estimate of pasture harvested for the Greenfield Farm 2006/07 and 2007/08, based on back calculations for the 244 days (1 June -31 January).

| | Cows/ha | Kg MS/cow | Kg MS/ha | Pasture eaten/cow | Pasture eaten/ha |
|---|---|---|---|---|---|
| Greenfield 2006/07 | 3.24 | 239 | 775 | 3057 | 9,903 |
| Greenfield 2007/08 | 3.32 | 277 | 913 | 3287 | 10,914 |
| RED Trt A 07/08 | 3.00 | 311 | 933 | 3494 | 10,482 |

These data are compared to that for the RED trial treatment A herd (Jensen *et al*., 2004) which operates a similar farm system in terms of imported feed but with a slightly lower stocking rate (the higher stocking rate for the Greenfield farm is due to the need to

match milk production/AMS and milk production per ha), and is managed at the nearby Scott Farm in Hamilton. The calculations do not allow for the silage conserved (481kg DM/cow RED trial, 333 kg DM/cow Greenfield).

The data show that, compared to the 2006/07 season, the Greenfield farm harvested more pasture and produced more MS/ha. Benchmarked against the RED trial the farm produced similar MS/ha but consumed more pasture due to the higher stocking rate. It is clear from these data that one of the key performance indicators (pasture harvested) for profitable pastoral farming systems can be achieved at a level equivalent to best practice conventional systems. Clearly the management changes put in place for the 2007/08 season which included allocation of three pasture breaks per day, a more flexible approach to managing cow traffic, and allocating a dedicated AMS for cows during the colostrums period, has seen a marked improvement in this measure.

*Farm production*

Figure 3 shows the milk solids production of the Greenfield farm for the past 4 seasons, by month of production. Prior to the 2007/08 season milk production (kg MS/cow) has been lower than equivalent conventional farming systems. The effects of the major drought that occurred in the Waikato region through the summer of 2008 (4.0 mm of rain in January, the lowest recorded for 100 years, and the soil moisture deficit was approaching 150mm in February) can be clearly seen in Figure 3 and in the full seasons production data presented in Table 5.

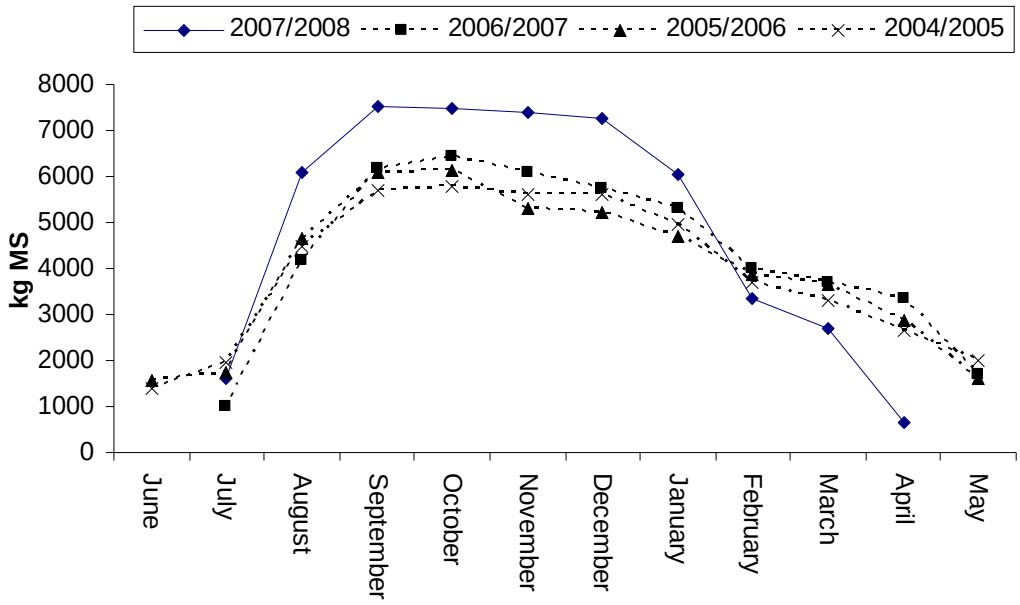


**Figure 3:** Milk Solids production for the Greenfield herd from 2004/05 through 2007/08

**Table 5:** Production data for the Greenfield herd for the 2006/07 and 2007/08 seasons.

| | Kg MS | kg MS/cow | Kg MS/ha | Kg MS/AMS | Cow milking days |
|---|---|---|---|---|---|
| 2006/07 | 54,993 | 320 | 1038 | 27,497 | 47,128 |
| 2007/08[1] | 55,012 | 314 | 1038 | 27,506 | 42,599 |

[1]Drought affected season.

Given the abnormal season, it is reasonable to use production to the end of January and extrapolate the seasons production based on the 2006/07 results from the Greenfield farm and this is presented in Table 6.

**Table 6:** Projected 2007-08 season production, based on actual production to January 2008, and then using the herd size reduction and production drop from the 2006-07 season.

| Date | Min Cows in milk | Av Cows in milk | Max Cows in milk | Total Milk | Average milk/day | kg milk | kg MS | kg MS/ha | kg MS/cow (175) |
|---|---|---|---|---|---|---|---|---|---|
| Jul-07 | 8 | 69 | 115 | 35,060 | 18 | 35,060 | 3,057 | 58 | 17 |
| Aug-07 | 115 | 140 | 162 | 88,174 | 20 | 123,234 | 10,606 | 200 | 61 |
| Sep-07 | 162 | 171 | 175 | 101,783 | 19.83 | 225,017 | 18,474 | 349 | 106 |
| Oct-07 | 173 | 174 | 175 | 99,821 | 19 | 324,838 | 26,539 | 501 | 152 |
| Nov-07 | 175 | 176 | 175 | 99,918 | 19.00 | 424,756 | 35,680 | 673 | 204 |
| Dec-07 | 175 | 176 | 176 | 96,079 | 17.62 | 520,835 | 42,396 | 800 | 242 |
| Jan-08 | 162 | 173 | 175 | 73,865 | 14.00 | 594,700 | 48,409 | 913 | 277 |
| *Feb-08* | *156* | *157* | *159* | *54,015* | *12.30* | *648,715* | *54,492* | *1,028* | *311* |
| *Mar-08* | *145* | *151* | *158* | *48,671* | *10.43* | *697,386* | *59,208* | *1,117* | *338* |
| *Apr-08* | *124* | *142* | *158* | *39,852* | *9.37* | *737,238* | *62,591* | *1,181* | *358* |
| *May-08* | *45* | *94* | *123* | *24,066* | *8.26* | *761,303* | *65,624* | *1,238* | *375* |

Since 2002, production performance has improved significantly at the Greenfield Farm such that it is now equivalent to best practice conventional farming systems. Importantly the research has shown that the key measure of pasture harvested can be achieved within a pastoral automated milking system with just 2.5% imported feed.

## Stradbroke Dairy, Winslow Ltd, Ashburton

The Stradbroke Dairy farm is situated south-west of Asburton near Mt Somers. The farm is a first year conversion to dairy having previously been used for cropping and sheep. The farm already operated two centre pivot irrigators but a new dairy has been built. The dairy design is based on experience working with a number of configurations in the United States and aims to offer maximum comfort for the cows. It is partially covered providing a dry area for servicing the four Lely A3 AMS and a comfortable working environment for staff.

**Stradbroke Farm Profile, 2008/09 season**

| | |
|---|---|
| Land area | 80ha effective |
| Cows | 280 Holstein Friesian, mixed age |
| Calving Pattern | Spring for 2008/09 then moving to year round |
| Staff | 1.5 |
| Hours of work | 8am – 5pm, on-call out of work hours duties shared among staff |
| Farming System | 65% feed grown on farm, 35% imported feed, heifers grazed off |
| Farm Layout Features | • Flat contour<br>• Farm divided into two main grazing areas around each pivot (A-B grazing). Cows will move from grazing area via the dairy and AMS to next grazing/feeding area. Cow selection for milking via AMS or selection box located in the dairy<br>• Central race bisecting each grazing area.<br>• Two Voyager grazing units (automated moving electric fence systems)<br>• Feedpad adjoining the dairy with separation area for attention cows |
| Irrigation | • Two centre pivots |
| Dairy Features | • Four Lely A3 automatic milking systems<br>• Single milk vat with a rapid wash facility |
| Technical Support | 24h support provided by Winslow Farm Technologies |

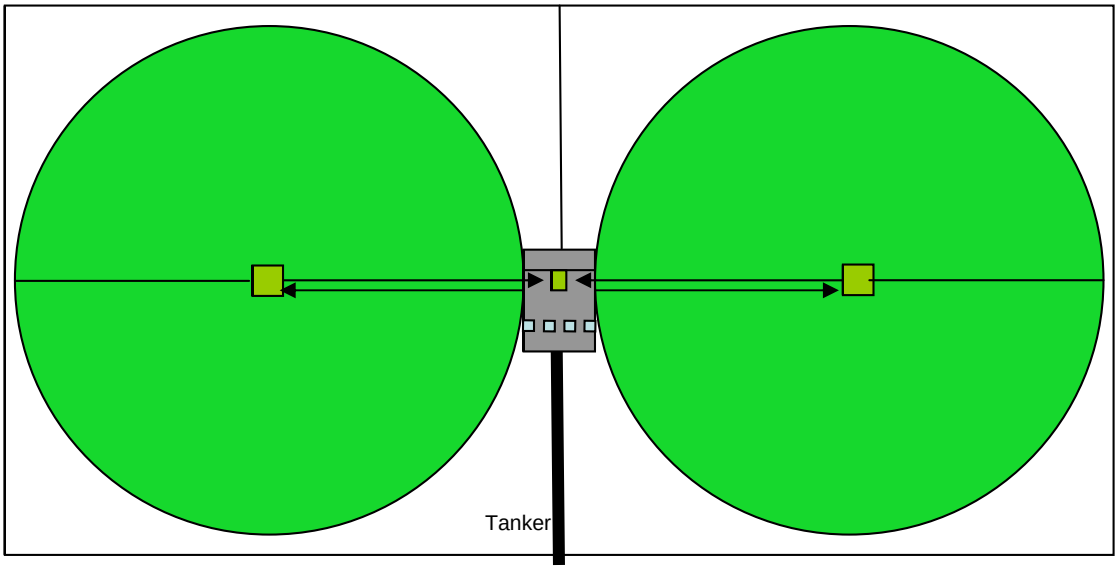


**Figure 4**: Stradbroke Dairy layout showing two centre pivot irrigators and raceway, central dairy housing four Lely A3 AMS.

*Herd*

280 Ambreed Holstein-Friesian, mixed age cows averaging 3rd lactation. For the first season calving will be spread across four months. This is due to the current pregnancy status of the herd (purchased from multiple farms) but should also serve to reduce workload during the training phase. The peak of calving will be in September. Calving will occur in 3 blocks beginning August (about 20% of herd), then continuing through September (50% of herd), with the balance calving in late October and November.

*Feeding and milking frequency*

Pasture will provide 65% of cows dry matter intake. Grain will make up the balance based on cow's individual production requirements. This will be fed during milking via the AMS. Some silage will be fed for about 45 days during the peak of the calving season. The farm has been re-sown with three different pasture mixes from Agricom (Max p fescue, Sterling, Ohau). Pasture trials will be conducted on this site.

On this farm the ratio of cows to AMS will be 70:1 (compared with Greenfield Farm of 90:1). As a consequence the farm will target a higher milking frequency per cow (at least 2x/day), while still aiming for high AMS utilisation.

*Training cows*

Cows will be trained in batches during the dry cow period. The hope is to have all cows trained to the robot system before they calve. The A3 training function in which non-

lactating cows can be fed in the box and the arm operating (but not attempting to milk the cow) will be used to assist with training the herd.

*Staffing levels*

The farm will be operated by a farm manager (Paul Berdell) and an agriculture exchange worker (8-months). Paul is an experienced AMS operator, having worked on several farms in the USA and also has some earlier experience dairy farming in New Zealand. The farm will utilise the services of a local farm consultant.

*Farm system performance*

While Winslow Feeds has numerous agricultural-related projects and interests the Stradbroke Dairy will be run as separate unit so the performance can be easily monitored. A monitoring program is being put in place, with assistance from DairyNZ staff, to collect performance data that can be used in future system evaluation.

*Technical support*

Winslow Farm Technologies will provide the technical support for this farm. Staff will be experienced AMS technicians and will be supported by Lely Industries from The Netherlands. The four AMS and farm operating system will be able to be accessed on-line from The Netherlands.

## References and further useful sources of information

If you are considering automatic milking for your farm it is important to research the different options thoroughly. Lely Ltd, De Laval, Fullwood (UK), WestfaliaSurge, SAC and Zenith all supply equipment internationally and Lely NZ are actively marketing the technology in New Zealand. Visit New Zealand and Australian research and commercial farms that have implemented automatic milking (DairyNZ Greenfield Project research farm, Hamilton; Stradbroke Dairy, Winslow Ltd, Ashburton; University of Sydney FutureDairy research farm; there is also at least two commercial farms operating in Australia and a second starting up in Southland, New Zealand). Take advantage of the knowledge of experienced independent DairyNZ researchers based in Hamilton or visit the DairyNZ website for more information.

Davis, K.L., Jago, J.G., MacDonald, K.A., McGowan, J.E. and Woolford, M.W. 2006. Pasture utilisation in a pastoral automated milking system. *Proceedings of the New Zealand Grasslands Association*, 68:81-86.

Davis, K., J. Jago, R. Wielczko, P. Copeman, K. Bright and M. Woolford. 2005. Optimising milking efficiency to maximise milk output from an automated milking system. *Proceedings of the New Zealand Society of Animal Production*, 65: 271-275.

Hedley,P., Kolver,E.S.,Glassey, C.B.,Thorrold,B.S., van Bysterveldt, A.,Roche,J.R.,Macdonald,K.A. 2006. Achieving high performance from a range of farm systems. Proceedings of the Dairy3 Conference 4: 147-165.

Jago, J., K Davis, P Copeman, I Ohnstad, M. Woolford 2007. In-bail feeding and minimum milking interval effects on cow traffic and milking performance in a pasture based automatic milking system, Journal of Dairy Research, 74:492-499.

Jago, J.G., Davis, K.L., Copeman, P.J. and Woolford, M.M. 2006. The effect of pre-milking teat-brushing on milk processing time in an automated milking system. *Journal of Dairy Research* 73 (2) 187-192.

Jago, J.G., Davis, K.L., Newman, M. and Woolford, M.W. 2006. An economic evaluation of automatic milking systems for New Zealand dairy farms. Proceedings of the New Zealand Society of Animal Production, 66: 263-269.

Jago, J.J., Davis, K.L., Wieliczko, R. and Woolford, M.W. 2006. The effect of stage of lactation on cow movement in a pasture-based automatic milking system. *Proceedings of the New Zealand Society of Animal Production*, 66: 258-262.

Jago, J.G., Bright, Copeman, P, Davis, K., Jackson, A. K., Ohnstad, I.; Wieliczko, R.; Woolford, M. 2004: Remote automatic selection of cows for milking in a pasture-based automatic milking system. *Proceedings of the New Zealand Society of Animal Production 64*: 241-245.

Jago, J.G., A. Jackson, K. Davis, R. Wieliczko, P. Copeman, I. Ohnstad, R. Claycomb and M. Woolford. 2004. Is automatic milking possible with a 100% pasture diet? *In* Automatic Milking: A better understanding (Eds) A. Meijering, H. Hogeveen, C. de Koning. p .

Jago, J. Jackson, A. and Woolford, M. 2003. Dominance effects on the time budget and milking behaviour of cows managed on pasture and milked in an automated milking system. *Proceedings of the New Zealand Society of Animal Production*, 63:120-123.

Jago, J., Copeman, P., Bright, K., McLean, D., Ohnstad, I. & Woolford, M. 2002. An innovative farm system combining automated milking with grazing. P*roceedings of the New Zealand Society of Animal Production*, 62:115-119.

Jago, J. & Woolford, M. 2002. Automatic milking systems: an option to address the labour shortage on New Zealand dairy farms? *Proceedings of the New Zealand Grasslands Association*, 64: 39-43.

Jensen, R.N.; Clark, D.A.; Mcdonald, K.A. 2004: Dairying intensification; production responses and financial implications. Proceedings of the Agronomy Society of New Zealand, 34, 13-20.

Lopez-Benavides, M.G., Williamson, J.H., McGowan, J.E., Lacy-Hulbert, S.J., Jago, J.G., Davis K.L. and Woolford, M.W. 2006. Comparison of mastitis for cows milked in an automated or conventional milking system in New Zealand. Proceedings of the New Zealand Society of Animal Production, 66: 252-257.

Woolford, M. and Jago, J. Automatic milking in New Zealand: Fact or fantasy? Proceedings of the South Island Dairy Event, pp.203-205.

Woolford, M., R. Claycomb, J. Jago, K. Bright, K. Davis, I. Ohnstad, R. Wieliczko, P. Copeman and K. Bright. 2004. Automatic dairy farming in New Zealand using extensive grazing systems. *In*: Automatic Milking: A better understanding (Eds) A. Meijering, H. Hogeveen, C. de Koning. p 280-285.