W 1188

AUTOMATIC MILKING SYSTEM CONSIDERATIONS

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Introduction

The terms automated milking systems (AMS), voluntary milking systems and robotic milkers are different names for the same technology: a stand-alone system that uses technology to milk dairy cattle with minimal to no human intervention. These systems can include laser guidance, udder mapping technology, individual teat attachment, feed delivery and individual cow identification with recordkeeping capabilities. These complex machines can be beneficial for both labor and management, but every farm has its own goals and practices. Before investing in these technologies, farms should consider the costs, potential benefits and operation fit. This publication provides a brief history of AMS and investment considerations, including impacts on labor, milk production, milk quality and maintenance. See the UT Extension Publication W 1005 "Precision Dairy That Pays" for additional considerations.

History

Automated milking systems were developed in Europe in the early 1990s to assist with labor issues on dairy farms (Lely, 2020). Since 1999, AMS have been used in Canada (Rodenburg and House, 2007) and in the United States starting in 2000 (Lely, 2020), with continued growth worldwide as shown in Figure 1 (Koning, 2010). As of 2014, there were over 2,500 AMS units in North America on ≥ 1,000 farms (Rodenburg, 2017). In 2017, the first AMS was installed on a Tennessee dairy farm. In 2022, Tennessee had 28 AMS units across eight dairies (an average of 3.5 AMS units per dairy; Palmer, 2022).

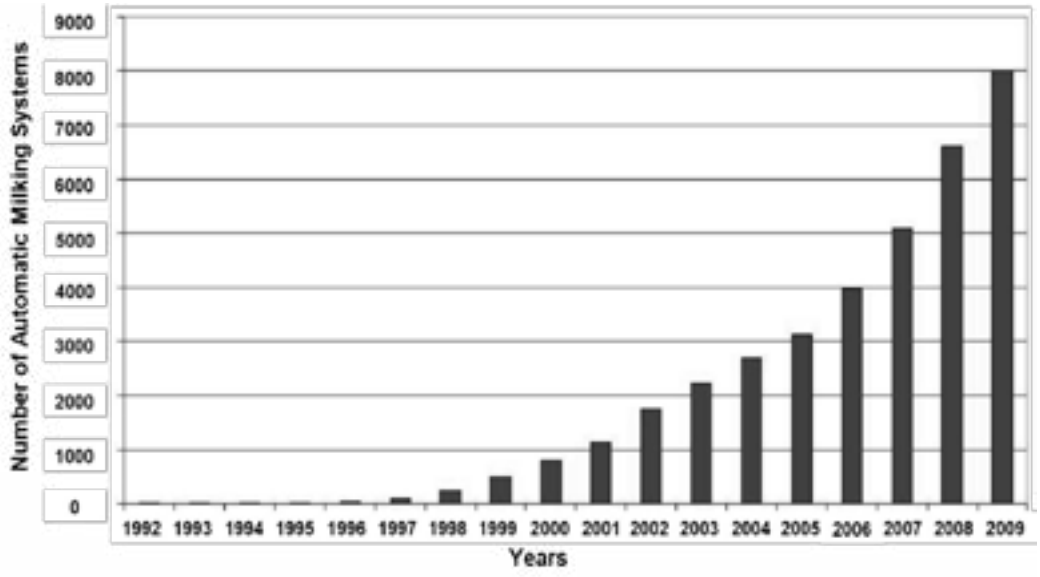


Figure 1.
Growth of AMS farms worldwide since their first introduction in 1992 (adapted from Koning, 2010)

Types of Systems

Automatic milking system companies currently include the following: BouMatic, Galaxy, GEA, Lely and DeLaval. The two primary robotic companies used in the southeastern United States are Lely and DeLaval (Rodenburg, 2002). All AMS have similar functions but may have design-specific differences or stated company missions that appeal to farmers. From a design perspective, DeLaval AMS use a central teat cup to prepare teats before milking, while Lely AMS have a rotating preparation brush (Figure 2). Each system has an end goal of safe and clean milk production and overall improvement of farm management; they just reach that goal by prioritizing farmer and cow needs in different ways (Lely, 2020; DeLaval, 2022). For example, DeLaval leans toward reproduction management and estrous detection, while Lely favors cow comfort and welfare (Lely, 2020; DeLaval, 2022). You should research each brand to determine which system aligns with your priorities and end goals. Take some time to visit dairies that currently use AMS, particularly if they are in your area. There may be subtle differences between the two you prefer after seeing them in action and visiting with existing users.



Figure 2.
Teat preparation image for Lely (left; Lely image) and DeLaval (right; DeLaval image)

Pre-Purchase Considerations

Labor

Before investing in AMS, consider the impacts on these primary areas: labor cost, milk quantity, milk quality and maintenance costs (Table 1). The initial startup process is very labor intensive, needing to introduce each cow to the system with someone present to help guide the AMS arm to the udder. After the startup process, the AMS reduce hours spent milking in a parlor and allow for more time on other job responsibilities, such as new AMS maintenance tasks, reproductive management, health management, and calf and youngstock management as well as flexibility in hours worked, time off or fewer workers hired. However, the workers must have the knowledge and understanding of the AMS (Kimpel, 2016). Workers who already have this skill or are asked to develop it may require higher salaries. Many studies contradict one another, with some stating that labor costs can decrease due to less labor needed, while others say that the labor used is more knowledgeable and requires a higher salary (Schulte and Tranel, 2013; Kimpel, 2016). Other labor benefits of AMS include the consistency the robot brings to milking cows through less human error in the parlor and adhering to the same milking procedure each time (Kimpel, 2016). Once the cow is introduced to the AMS, information specific to that cow is recorded, including udder shape, expected production per quarter, expected milking time and milk temperature. The records collected from the AMS are used to improve labor and management practices of the farm (Schulte and Tranel, 2013).

	Pro	Con
Labor	• Reduced hours spent in a milking parlor (Kimpel, 2016) • Consistency across cows and the milking process (Kimpel, 2016) • Cow-specific milking information and attachment (learns the udder pattern; Schulte and Tranel, 2013)	• More skilled labor is required to manage the computer systems and the robots (Kimpel, 2016) • Requires more understanding of electronics and managing cow data • Labor cost may be similar before and after AMS with difference being that AMS labor requires fewer but more knowledgeable employees
Milk Production	• Increased milk production in herds milked two times a day in a parlor (Castro et al., 2012)	• A slight milk production decrease in herds milked three times a day (Castro et al., 2012)
Milk Quality	• Mixed results in somatic cell count - No difference (Helgren and Reinemann, 2006) - Increase SCC (Klungel and Slaghuis, 2000) - Decreased SCC (Shoshani and Chaffer, 2002)	• Research showed increased freezing point, free fatty acids and total bacterial counts (Vorst et al., 2002, Tremblay et al., 2016b) • Lower milk fat and protein concentrations due to increased milkings (Speicher et al., 1994, Shoshani and Chaffer, 2002)
Maintenance	• Some costs are covered by service contracts with installation groups	• Daily, weekly, monthly and yearly maintenance requirements • Each manufacturer recommends additional maintenance protocol

Table 1.
Pros and cons of automatic milking systems regarding labor, milk production, milk quality and maintenance

Milk Production and Quality

Research shows a 3 percent increase in milk production per AMS with an average of 2.4 to 2.6 milkings per cow per day compared to conventional milking systems (Castro et al., 2012). For farms milking two times a day, this increases milk production per cow per robot (Tremblay et al., 2016a, Tremblay et al., 2016b). However, if the farm milks three times a day, it potentially lowers milk production due to fewer milking coming from the AMS (Tremblay et al., 2016b). Studies have investigated somatic cell count (SCC) before and after the installation of AMS. Results from these studies do not provide a clear consensus on the impact of SCC before and after the installation of AMS. Contradicting results have shown no change (Helgren and Reinemann, 2006, Salovuo et al., 2015), an increase (Klungel and Slaghuis, 2000, Rasmussen et al., 2002, De Koning et al., 2003, Johansson et al., 2017), or a decrease (Shoshani and Chaffer, 2002, Tousova et al., 2014, Bentley et al., 2018) in bulk tank somatic cell count (Table 2). Talk to your county Extension agent or state specialist to review your milking quality information and find what works best for you.

Variable	Source	Change	Number Results	Significant
Somatic cell count	Helgren and Reinemann, 2006	No change		No
	Saluvuo et al., 2015	Increase	142,000 to 208,000	No
	Klungel and Slaghuis, 2000	Decrease	233,000 to 217,000	No
	Bentley et al., 2018	Decrease	257,000 to 165,000	Yes
	Tousova et al., 2014	Decrease	222,000 to 163,000	Yes
Milk production (total lbs.)	Koning et al., 2003	Increase		Yes
	Bentley et al., 2018	Increase	69.0 to 77.5	No
Milk components (fat %)	Saluvuo et al., 2015	Increase	3.85 to 4.03	No
	Tousova et al., 2014	Increase	4.05 to 4.21	Yes
	Jahansson et al., 2017	Decrease		No

Table 2.
Somatic cell count, milk production and milk component differences following AMS adoption

Maintenance

Like all equipment, AMS require daily, weekly, monthly and yearly maintenance. Lack of maintenance or cleaning can lead to difficulty locating teat ends, system sounding alarms, or even system shutdowns. To prevent or reduce problems, cameras, lenses and feed stations should be routinely cleaned, and downtime should be scheduled so the AMS can conduct internal cleaning (Kerrisk and Monks, 2014). The AMS needs system cleanings up to three times a day (Kerrisk and Monks, 2014) with weekly checks and monthly preventative maintenance (Kerrisk and Monks, 2014). Each system's unique recommended maintenance times and supply replacement guidelines are listed in its manual.

Maintenance will require time and money. There are programs or contracts with installation groups that help cover the cost of these major maintenance or repair items, but time can still be an issue (Rodenburg, 2002). Table 3 provides a sample AMS maintenance schedule. A relationship is required between the salesperson and the farm. When considering AMS, evaluate and confirm that your salesperson will provide reliable service and advice when needed. The best technology can be useless without a good service team behind it. Each AMS brand may have a different timeline for maintenance. It is recommended to familiarize yourself with the brand's maintenance timeline before purchasing an AMS. Links to some guidelines can be found below:

- Lely timeline: HERE
- DeLaval timeline: HERE
- GEA timeline: HERE (page 73)

Daily	Weekly	Six Months
• Clean robot thoroughly inside and out • Change filters • Brush up feed • Examine any alarms	• Check chemical and teat dip levels	• Replace hose pump
One Year	**Three Years**	**Number of Milkings**
• Replace all hoses • Check filling position and adjust if needed	• Replace (if needed) chain, driving pinon and chain sprocket • Replace hose pump	• Replace teat cup liner every 10,000 • Replace milk pump bladder every 40,000 • Replace shutoff sleeve every 30,000 • Replace cleaning brushes every 30,000

Table 3.
General maintenance timeline suggested for automated milking systems adapted from Lely, DeLaval and GEA timelines

Identification Methods Needed

Automatic milking systems require cow identification through an electronic ID that can be a radio frequency ID (RFID) ear tag, neck collar or leg tag. This allows the AMS to record information from the cow, remember teat locations, present individualized data, and collect data from the cow and milk samples. For many AMS systems, after a cow is programmed into the robot at startup, the AMS remembers the mapping of her udder so the next time she milks the hybrid arm knows where to place the cups. The AMS system will collect and display records on the temperature of each teat, the feed given and consumed, box time and milk letdown time, fat and protein concentrations, and milk electroconductivity.

Cow Flow

Automatic milking systems have two primary forms of cow movement: guided flow and free flow. Movement, or flow, refers to how cows interact with the AMS and the rest of their environment. Guided flow requires the cow to pass through the robot to either eat or lie down. There are two types of guided flow systems, feed first and milk first, as seen in Figure 3 (Rodenburg, 2017). In feed first, the cows have access to the feeding alley but must travel through sort gates and the robot to get to the resting area. In milk first, the cows are in the resting area and must travel through the robot to get to the feeding alley. With free flow, the cow has continuous access to food and rest and can go to the robot when it best suits her (Rodenburg, 2017).

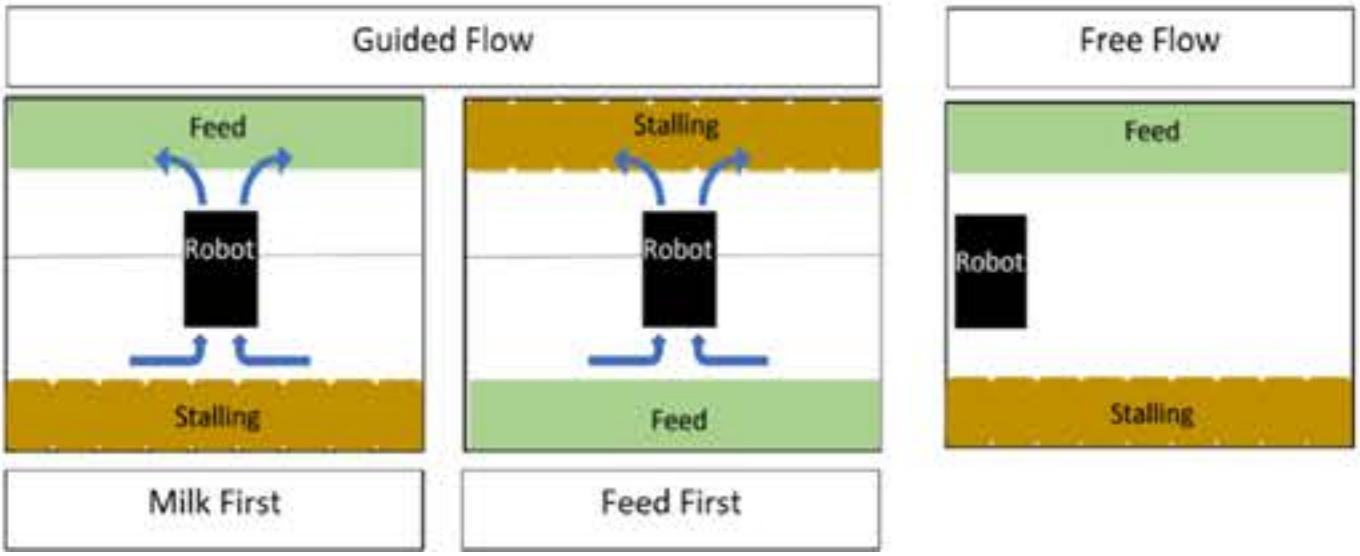


Figure 3.
Cow travel pathway through guided flow (left) and free flow (right) barns

Each flow system has potential benefits and limitations. Public perception may be concerned with guided flow because cows are routed through the barn and do not have the freedom to choose their behavior (Rodenburg, 2017). Regarding milk production, Tremblay et al. (2016a) reported that milk production per cow and per robot were 1.1 pounds per day and 147.7 pounds per day higher, respectively, with free flow than with guided flow. Also, with free flow, the cattle ate more meals (8.6 per day) than with guided flow (6.6 per day), increasing their feed intake (Harms et al., 2002). There were more milkings to the AMS with guided flow (2.6 per day) compared to free flow (2.3 per day; Harms et al., 2002). Hermans et al. (2003) completed a study comparing the two systems and the percentage of time the cows completed certain activities over 72 hours (Table 4). In a side-by-side comparison, cows ate less, stood longer, spent less time lying, spent less time in the waiting area, and spent less time in the AMS in a guided flow system than in a free flow system.

	Guided Flow	Free Flow
Eating (%)	16.7	17.0
Standing in free stalls (%)	12.9	9.7
Standing on floor (%)	51.8	50.0
Lying (%)	18.7	23.2
Waiting area (%)	5.3	6.1
In AMS (minutes per day)	43.0	55.0

Table 4.
Time budgets across activities in cows milked with guided flow versus free flow (adapted from Hermans et al., 2003)

Construction Process

An AMS aspect that should not be overlooked is the construction process. You must have a qualified and experienced construction team installing the equipment. Keep the construction area open with limited obstacles, keeping it clear and easy for cows to access (Palmer, 2022). Plan long-term (10 + years) with room for expansion (Palmer, 2022). Many producers who did not think they would expand ended up adding more robots and cows (Palmer, 2022). Research and visit other AMS farms to get an idea of what is best for you. Many companies selling AMS will have general layouts to reference when making decisions. An example layout is shown in Figure 4.

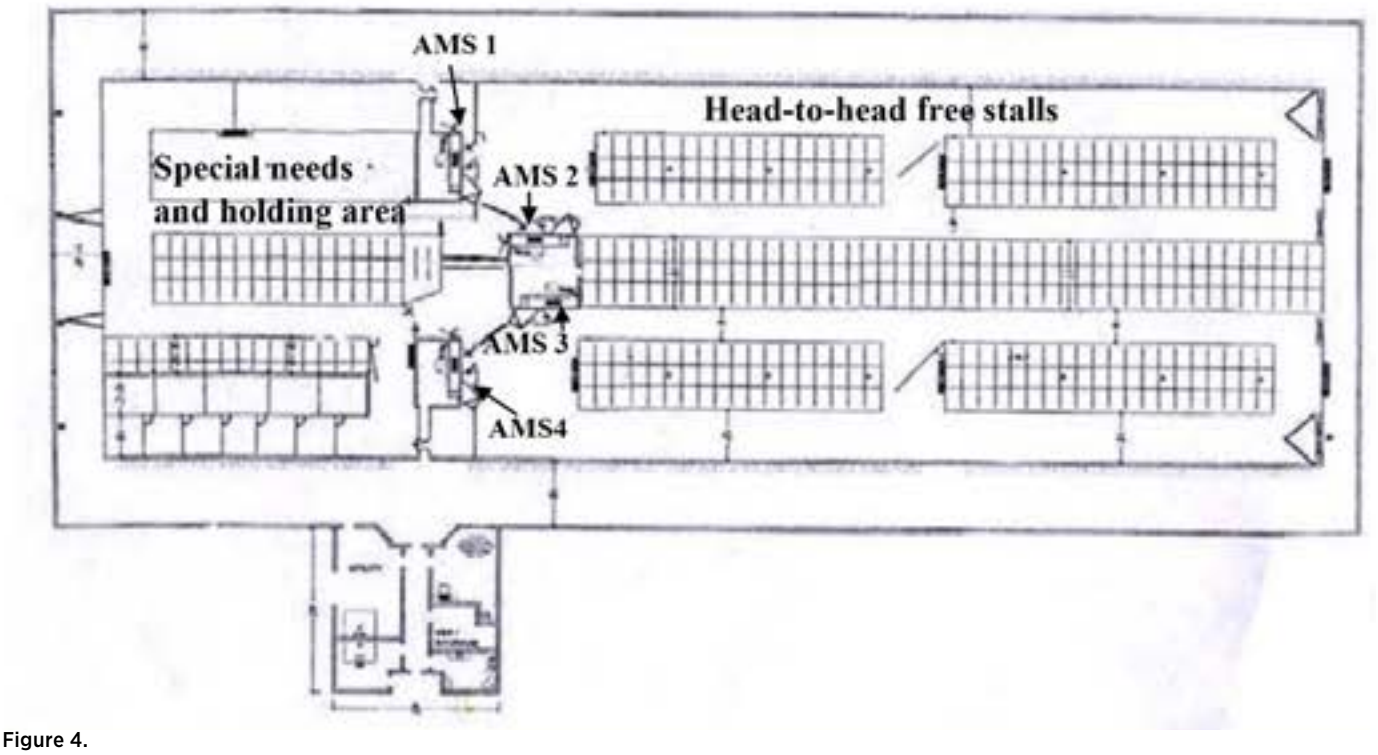


Figure 4.
Example AMS barn layout for ~240 milking cows and four robots (AMS 1 through 4) with a separate area for special needs animals or holding area (adapted from Rodenburg, 2010)

Post-Purchase Considerations

Feed Change/Cost

Feed cost per pound and intake amount changes can be significant with AMS installation. Feed intake positively correlates to milk production (Schulte and Tranel, 2013) and should increase in AMS systems, particularly those moving from twice-daily milking. Pelleted feeds are recommended for AMS due to issues with the dustiness of commodity feeds that can impact AMS electronics. Higher-quality pellets (i.e., greater nutritive value and less dust) are more expensive. However, research has shown a decrease in total feed costs because cows are fed individually rather than in groups (Rodenburg, 2002). Higher-quality pellets may be more expensive but have shown an increase in milk production and animal health. Research has shown an increase ($0.005 higher costs per pound) in feed costs for AMS cows compared to cows milked in conventional parlors (Rodenburg, 2002).

Management

Management for an AMS operation goes beyond the traditional dairy farm tasks and adds the management of a complex technology system. Because of this, managers must have the ability to incorporate management software and data-based decisions into their operation. On the cow side, managers must consider milking time and udder conformation. Cows with increased milking speed will allow more cows and more milk production per robot (Rodenburg, 2017). While benchmarks have not been set with an AMS herd, Tremblay et al. (2016a) found an average box time of 6.8 minutes per milking on 2.9 milkings per cow and 50.5 cows per robot or 147 milkings per day. Cows with poor udder conformation result in longer box times due to slow or failed attachments (Jacobs and Siegford, 2012). These cows often turn into fetch cows (defined below). Therefore, udder conformation plays a vital role in selecting robot cows. However, robots can do a surprisingly good job of adapting to different udder conformations (Rodenburg, 2002). Do not assume you must cull a cow based on her udder conformation until you test her with the robot.

Fetch Cows

Fetch cows are one of the biggest issues in AMS systems. Fetch cows are determined by how long they have been away from the robot (i.e., time since the last milking). In 2001, Canadian farmers recorded that 10 to 15 percent of the herd did not voluntarily milk in the robots and an average of 19 percent of cows had to be fetched by the farmer (Rodenburg and House, 2007). A survey showed that 14.6 ± 10.3 percent of cows were fetched between one and two times a day. It should be noted, however, that the number of cows that had to be fetched ranged from a low of 2.5 percent to a high of 41.6 percent of the herd (Rodenburg and House, 2007). A recent study in Tennessee found that 80 percent of the herd showed up on the fetch list at least once in a seven-month period, but only 5 percent of cows showed up on the fetch list on a given day (McCalmon, 2023). Of that 5 percent, only 4 percent were fetched by the farmer (McCalmon, 2023). Research is still limited on when cows should be fetched, the financial impact of fetch cows, and if the time away from the robot should be the primary indicator of success.

Real Life Evaluations

In a survey conducted from May 2014 to June 2015, Canadian producers were asked about their experience with cow training, training challenges, quality of life changes and overall satisfaction level with AMS. Most training group sizes were < 20 (63 percent), and mature cows were required to visit the robots at least twice daily. Both heifers and cows average seven days to train, while the whole herd takes about 30 days to train. An average of only 2 percent of the herd were culled from farms due to the AMS. The challenges of transitioning included learning AMS, training cows, feed changes, trusting the system, the demanding first few days and health management changes. Other less-seen challenges were general maintenance, cow traffic, too much milk, needing more robots and not liking the technology. It should be noted that these producers were on a quota system; however, the potential issue of needing additional milk storage and ensuring a market for any excess milk should be addressed. Of the surveyed producers, 86 percent recommended transitioning to AMS, 13 percent recommended transitioning depending on who they are talking to (technologically savvy farmers), and 1 percent did not recommend transitioning to an AMS. Overall, AMS has an improvement on time flexibility, less work stress, employee management and the quality of the farmer's and cows' lives (Tse et al., 2018).

Budgeting

Automatic milking systems over time are meant to reduce labor costs and increase profit. However, the initial AMS investments are costly. In 2017, for a 120-cow confinement operation, the AMS investment cost $375,000 (for two units; Salfer et al., 2017). Over time, investment has risen with inflation as well as rapid demand growth. As of 2016, there were over 35,000 AMS worldwide with an 8 percent increase in sales from 2013 to 2014 (Kimpel, 2016), and the payback period for the robots spanned an average of seven to 10 years (Schulte and Tranel, 2013).

In 2018, Iowa State University completed a partial budget for a 216-cow herd. Their basis was for installing three AMS for $250,000 per unit, including AMS housing. They came to a yearly maintenance cost per robot of $7,000. The expected usefulness of each robot is about 15 years, and each robot has a salvage value of approximately $35,000. This budget exercise resulted in a negative cash flow (Tranel, 2018). For more economic information, the Iowa State University partial budget can be found here (Schulte and Tranel, 2013). Salfer et al. (2017) reported that most economic simulations and studies showed that AMS were less profitable than conventional milking systems. However, it is important to note that as labor costs increase, AMS become more cost effective.

Conclusion

Key takeaways:

- Consider your barn's current layout and possible construction changes.
- Training or additional skills may be required to manage an AMS dairy.
- Research which brand of AMS aligns with your goals and outcomes from the robots.
- Understand the cash flow required to add an AMS as well as the return on investment for the system.
- Always keep an open mind to technology and the willingness to change.
- Know your farm and your limits to determine if robots are right for you.

For more information or to discuss how AMS could fit with your operation, please contact your local county Extension agent or Dr. Liz Eckelkamp at eeckelka@utk.edu or (865) 974-8167.

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