FARMERS’ BEHAVIOR IN USING AUTOMATIC MILKING SYSTEMS AT DAIRY FARMS

A study investigating the influence of management factors on the efficiency of the automatic milking system.

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Preface

The duration of this research was six months, excluding two months of holidays, the research started in May 2016 and ended in December 2016. While writing this thesis I learned a lot about automatic milking systems and what is necessary to make these systems efficient. I also developed my personal skills and competences, I mainly improved my ability to make my own choices and to stand behind these choices. This subject interested me because it involved sensor technology used for livestock and on-farm management. I think these two aspects are an interesting combination because especially in dairy farming, management on farms is very different. Since dairy farmers have such different approaches in managing the farm, it is interesting to see which aspects could have an effect on the efficiency of the technology. I think if we look further into these subjects it might be possible to identify if farms can benefit from technology such as an AMS before the investment is made. Which is quite convenient since these technologies are often big investments.

Furthermore I want to thank Kees Lokhorst, who is Lector Herd Management and Smart Dairy Farming and is a researcher at Wageningen UR Livestock Research, for his help and supervision when needed. His knowledge about dairy farming and sensor technology was an added value to this research. Also I want to thank Guust Swarte, who works part-time at Wageningen University and is the CEO of Swarte Innovation Development, for his supervision. He supervised on the management aspects in this thesis and I really appreciated his point of view on the research. Both supervisors supported me well through the process and also enabled me to implement my own ideas into the research. This made me more confident in making my own choices concerning the research. Furthermore I want to thank all the farmers who cooperated in the data collection phase, it was absolutely amazing to visit all the different farms and to get an insight in your work routines and hear about the passion you all have for farming. And lastly I want to thank Arjen van der Kamp, who was my contact person at Lely, for providing me with the necessary information to conduct this research.
Abstract

Purpose. Since it has been shown in recent studies that that the Automatic Milking System (AMS) did not deliver the promised performances to farmers and several studies stated this was caused by the differences in management practices on the farms. The aim of this study was to identify which management practices are used on a dairy farm, which factors influence the performance of the AMS and how these factors be changed to improve performance of the AMS.

Materials and Methods. A literature review was conducted to find the different factors that influence the performance of the AMS found in previous studies. After this the interview was set-up and the customer journey was determined as method to use for the observations. For data collection Lely was asked to cooperate and provide us with the contacts of the farmers. Judgmental selection was used to determine which farmers where included in the sample size. Subsequently data was collected on fourteen farms. The sample size existed of fifteen farms, however one farmer canceled at the last moment and a new appointment could not be made due to time constraints, he did send his results via e-mail and some of these results could be used.

Results. An interesting finding is that all overall farmers used between 53% and 64% of the available data. Thereby proactive behavior and number of discussion partners was associated with a higher milk yield per minute. Additionally the farmers in the high milk yield group were contempt with the instructions of the supplier however in the other groups results where more inconsistent. Perceived ease of use was also better in farms with high milk yield per minute.

Conclusions. Overall the farmers in all different milk yield groups conduct the same tasks in their morning routine and all of them do not use all the available data. Instructions and support can be optimized to improve data usage and the perceived ease of use. Thereby the farmer can improve efficiency by finding more discussion partners and conduct proactive behavior.
Management Summary
De management samenvatting zal geschreven worden in het Nederlands ter informatie voor de boeren die hebben meegewerkt aan het onderzoek.

Doelstelling en onderzoeksvragen
Het aantal automatisch melksystemen in Nederland is nog steeds aan het stijgen. Uit recent onderzoek is gebleken dat de voordelen die boeren verwachten te krijgen met het implementeren van een melksysteem, niet altijd tot uiting komen. Verschillende onderzoeken schrijven deze gebeurtenis toe aan de verschillen in management tussen boerderijen. Daarom is de doelstelling van het onderzoek het bepalen van welke management factoren invloed hebben op de efficientie van een automatisch melksysteem op melkveehouderijen, door het observeren en begrijpen van verschillende processen en activiteiten op de melkveehouderij. De hoofdvraag opgesteld is: Welke verschillende management factoren worden op dit moment gebruikt op melkveehouderijen, en hoe kunnen deze worden beïnvloed om de prestatie van het AMS beter te maken? De zes onderzoeksvragen die zijn beantwoord voorafgaand aan deze vraag zijn:

- Onderzoeks vraag 1: Welke factoren kunnen worden gevonden in de literatuur die invloed hebben op de prestatie van het AMS aangaande eigenschappen van de boer, de boerderij en het AMS?
- Onderzoeks vraag 2: Welke functies heeft het AMS dat gebruikt wordt door de boeren in dit onderzoek en hoe kunnen deze functies worden gebruikt?
- Onderzoeks vraag 3: Welke eigenschappen van de boerderij hebben invloed op de efficiëntie van het AMS?
- Onderzoeks vraag 4: Welke eigenschappen van de boer hebben invloed op de efficiëntie van de AMS?
- Onderzoeks vraag 5: Welke eigenschappen van het AMS en bijbehorende service hebben invloed op de prestatie van het systeem?
- Onderzoeks vraag 6: Wat kan er veranderd worden door de boer die het AMS gebruikt of door de fabrikant van het AMS om de prestatie van het AMS te optimaliseren?

Methodes
In totaal is er op veertien boerderijen data verzameld, de steekproef bestond uit vijftien boerderijen maar één boer heeft de afspraak af moeten zeggen. Hij heeft de vragen van het interview wel ingevuld en toegezonden via mail, sommige resultaten konden daarom toch worden meegenomen. De boeren zijn door Lely geselecteerd door middel van ‘judgemental sampling’, er is een lijst van 73 boeren geselecteerd waarvan Lely dacht dat
zij interesse hadden in tijd registratie, efficiëntie management en onderzoek. Al deze boeren zijn gevestigd in het oosten van het land. Er is gekozen voor een gestructureerd interview met van te voren opgestelde vragen, zodat de antwoorden nog vergelijkbaar waren. Voor het observeren is de customer journey gebruikt zodat elke verschillende gedraging genoteerd kon worden en daarbij welke technologie er werd gebruikt door de boer. De interviews en observaties zijn niet beschikbaar gesteld bij dit rapport omdat deze vertrouwelijk zijn, de begeleiders van dit onderzoek hebben wel inzicht gekregen in het project archief. De efficiëntie van het AMS zal getoetst worden aan de hand van het kengetal melk gift per boxtijd (liters/minuut).

**Resultaten**

De belangrijkste resultaten zijn dat er maar twee boeren zijn die meer dan 70% van de beschikbare data gebruikte. De rest van de boeren gebruikte tussen de 53% en de 64%, daaruit kan geconcludeerd worden dat boeren inderdaad niet alle opties en functies van het systeem gebruiken. Dat dit daadwerkelijk van invloed is op de melkgift per boxtijd is niet bewezen in dit onderzoek. Echter zijn er wel een aantal factoren die wel van invloed zijn op de melkgift per boxtijd, namelijk; proactief gedrag van de boer, het aantal sparring partners, de instructies en hulp van de fabrikant, perceived ease of use en de beschikbaarheid van grasland.

**Conclusies en aanbevelingen**

Over het algemeen voeren de boeren in de ochtend routine dezelfde taken uit, het zijn echter de routines en de besluitvorming van de boeren die ook een invloed lijken te hebben. Het leek alsof routines in boerderijen met een lage melkgift per boxtijd minder structureel waren, dit is een interessant onderwerp voor vervolgonderzoek omdat we dat in dit onderzoek niet voldoende konden leggen met de gekozen methodes. Boeren wordt aanbevolen om meer proactief te zijn in het handelen met het systeem en monitoren van de koeien, dit heeft een positieve invloed op de melkgift per boxtijd. Bovendien is het aan te raden ideeën en problemen die op de boerderij ervaren worden regelmatig te bespreken met college boeren. En als laatste wordt boeren die weidegang hebben aangeraden om nooit minder dan vier uur per dag toegang te geven, dan kan dat negatieve gevolgen hebben op de melkgift per boxtijd. De fabrikant kan de boer helpen door de instructies over het management systeem en ondersteuning bij implementatie van het AMS te optimaliseren, dit kan ervoor zorgen dat de perceived ease of use hoger wordt en daarmee het gebruik van gegevens door de boeren.
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1. Introduction

When a company wants to innovate there are four different strategy possible. The four different strategies which can be used are (1) market penetration, is increasing the market share in an existing market with existing products or services using different strategies (e.g. price adjustments and increased promotion), (2) product (or service) development, so presenting new or altered products (or services) to an existing market, (3) market development is offering existing products (or services) to a new market or (4) conglomerate diversification, where an organization develops a new product (or service) and enters in a new market (Johnson et al., 2015). For the companies developing technology for the livestock sector the introduction of the automatic milking system (AMS) was a chance to change strategy and offer farmers the chance to innovate. Many agriculture technology developing companies (e.g. Lely, DeLaval, GEA, Fullwood and SAC) have been developing this product in the past dozen of years and are offering it in their existing market which gives farmers the opportunity to innovate. So when the AMS was firstly developed these companies had a product development strategy, to introduce this product into their existing market. Nowadays the AMS is developed and introduced into the market, and the agriculture technology developing companies are focused on increasing their market share by for example using market penetration strategy.

The amount of innovating dairy farms increased with 13% from 2011 until 2013. Innovation in this case means implementations of important technical innovations on the farm (van der Meer and van Galen, 2015). Van der Meer and van Galen (2015) but also Johnson et al (2015) identified two types of innovations which can occur: process innovation and product (or service) innovation. Process innovation is a change which is conducted to significantly improve the production and distribution processes of a product (or service). Product (or service) innovation is an introduction to the market of either a significantly improved product or an entirely new product (Johnson et al., 2015). In dairy farms, process innovation occurs more often, as stated earlier in total 13% of the dairy farms implemented an innovation from which 11% was process innovation, 1% was product innovation and 1% was a combination of product and process innovation (van der Meer and van Galen, 2015). Process innovation in dairy farming is for example implementation of automatic milking systems or automatic feeding systems.
This research will look into farms using an automatic milking system (AMS) and thus in farmers who conducted a process innovation. Currently approximately 20.5% of the Dutch dairy farmers use an automatic milking system (Stichting KOM, 2016). Figure 1 shows that at least since 2010 the purchase of the automatic milking system has been increasing. This might have been a sequel to the abolishment of the milk quota in April 2015. Because a lot of farmers expanded their farms after the announcement regarding the abolishment of the milk quota in 2010, to be able to produce more milk.

Figure 1 Number of automatic milking systems (AMS) in the Netherlands over the years (Hogenkamp, 2016; Stichting KOM, 2016; Stichting KOM, 2013; Veeteelt, 2015; Veeteelt, 2013)

Since technology is developing fast the AMS can already be used for more purposes than just automatic milking. In most of the cases sensors are attached to the AMS. Examples of attached sensors are the color sensor, the somatic cell count (SCC) sensor, the electrical conductivity sensor and a weighing platform (Steeneveld and Hogeveen, 2015; Rutten et al., 2013). The color, SCC and electrical conductivity sensors can be used to detect mastitis in an early stage. A recently conducted study stated that it is not known to what extend farmers use the sensors and the data obtained from the sensors and the AMS or if they even use it at all (Steeneveld and Hogeveen, 2015). Thereby the most frequent reason that farmers have sensors attached to their AMS is that they were included as standard or they could be purchased at reduced cost with the AMS. Main reasons to invest in sensors attached to AMS, when farmers consciously chose to do so, are reducing labor and alleviating herd management (Steeneveld and Hogeveen, 2015; Heikikilä et al., 2012). Which are in line with the reasons for farmers to invest in a AMS in general namely: 1) less labor, 2) increased flexibility, 3) the possibility of milking cows more than twice per day, 4) leaving of an employee and, 5) need for a new milking system (Hogeveen et al., 2004).
However, Steeneveld et al. (2015) stated that total labor time was not lower when AMS was implemented. While the decrease of labor time was an important factor for farmers to invest in AMS and the sensors attached to AMS. Several explanations were given to explain this result of Steeneveld et al. (2015): 1) farmers plan a transition to more cows after implementing an AMS, and therefore the extra time created by the use of AMS and its sensors is then spent on labor tasks which are caused by the expansion, 2) the saved labor time after investment might not be as big as expected and therefore is used in ‘new’ labor tasks such as interpreting data and checking alerts, 3) farmers might record a full FTE for themselves regardless of the actual working hours per year (Steeneveld et al., 2015). Subsequently, Steeneveld et al. (2012) did not find any differences in labor costs between an AMS and a conventional milking system (CMS) and gives exactly the same reasons as stated above for this finding. Bijl et al. (2007) however did find that farmers using an AMS on average use 29% less of their own labor time compared to farmers using an CMS. A possible explanation is that farmers invested in AMS in 2003 (Bijl et al., 2007) were not aware of the upcoming abolishment of the milk quota in 2015, and therefore did not necessarily focus on expansion so they saved time. While the farmers in the study of Steeneveld et al. (2012) invested in AMS later and therefore were aware of the abolishment of the milk quota in the future causing that these farmers focused on increasing size of the farm instead of decreasing labor time.

Another finding in the study of Steeneveld et al. (2012) is that the milk production when transferring to AMS increases while the SCC also increases. While the increased milk production is caused by a higher milking frequency (Kruip et al., 2002; Wagner-Storch and Palmer, 2003; Speroni et al., 2006) the rise of SCC is probably caused by the change in management. The AMS mastitis detector systems are not perfect and have been reported to miss 75% of the clinical mastitis cases (Kamphuis et al., 2010; Rutten et al., 2013). However in CMS farms the mastitis detector system does reduce SCC, which is due to the fact that in this system the farmer is present while milking so the cow can still be visually inspected. Subsequently, the choice for a mastitis detector system in a CMS is made deliberately, this might cause the farmers to use the system more intensively (Steeneveld and Hogeveen, 2015).

Concluding, not all farmers get the expected advantages from the AMS and several researches state that this might depend on different ways of management and behavior of the farmer, so efficiency of the AMS is affected by the management of the farmer (Hansen, 2015). Therefore this study will examine how differences in management affect efficiency of the AMS at a farm, and how efficiency of an AMS can be improved.
1.1 Research objective

The objective of this research is to be able to quantify which key management aspects influence the efficiency of the AMS on dairy farms, by observing and understanding, processes and activities on different dairy farms, this will result in a comparison between farms to find the influencing factors.

1.2 Key concepts and definitions

The key concepts and definitions are frequently used and essential for understanding this research. Therefore they are listed below.

**AMS (Automatic Milking System):** The automatic milking system is the whole system that makes it possible to successfully use a robot to milk cows, so including cleaning techniques, monitoring technologies and controlling software etc.

**Milking unit/robot unit:** the box in which the cows are milked and the technology needed to make the milking possible.

**AMS efficiency:** the efficiency of the AMS is expressed in milk yield per minute per boxtime.

**AMS performance:** In this research AMS performance looks at the overall performance on the farm, so besides milk production among others, claw health, udder health, fertility and perceived usefulness are taken into account.

**Lely Astronaut (A4, A3, A2):** The Lely Astronaut is an automatic milking system developed by Lely. A2, A3 and A4 stand for different versions of the AMS.

**Box time:** Amount of minutes the cow spent in the robot unit when milked.
2. Problem analysis

In different studies is stated that different results appear while examining AMS and the attached sensors (Bijl et al., 2007; Kamphuis et al., 2010; Rutten et al., 2013; Steeneveld et al., 2012). As stated before farmers often invest in AMS because of certain expectations about the advances of the system (e.g. decrease labor, increase flexibility and increase number of milkings per cow per day) (Hogeveen, 2015). Thereby AMS producers also promise that production and cow health will be increased and labor costs will be reduced when using an AMS. Since several studies did not show any difference regarding these factors after implementation of the AMS and some studies did find differences, it would be interesting to know what causes the results to be so different.

Hansen (2015) identified that different management practices should be investigated as an effect on the performance of the AMS at a farm. The AMS is considered the problem owner because it is being used inefficiently. And several factors for example the farmer and the characteristics of the farm can affect this performance. Steeneveld et al. (2015) also identified that information and guidance provided about the AMS by the producer could improve the technical performance of the farms.

2.1 Background information

Research containing the AMS as a subject started mostly in the nineties, where the main objectives where either to study the effect of AMS on cow welfare and health (Ketelaar-de Lauwere et al., 1996; Winter et al., 1992; Winter & Hillerton, 1995) technical aspects in the AMS such as teat cleaning and inspection (Bull et al., 1995; Schuiling, 1992), finding appropriate methods for implementation of the AMS, effects on milk production (Ipema et al., 1988), effects of feedings strategies (Prescott et al., 1996; Pirkelmann, 1992) and labor conditions and organization in a farm using an AMS (Belt & Zegers, 1984; Sonck, 1996). These studies focused on the development and improvement of the AMS to make it more attractive and easy for farmers to implement. Without these researches farmers would not know what the effects of the robot are and if they are positive or negative. The AMS has now been developed, however development never stops, the focus of using an AMS is changing and it can be seen that the focus of studies is also changing. The technology is less seen as the factor to be improved to make the use of the AMS as efficient as possible, as stated above farm management is mostly expected to be an improvement point.

Several studies on efficiency have been conducted, assessing different types of efficiency e.g. technical efficiency (Steeneveld et al., 2012), profitability (Shortall et al., 2016; Bijl et al., 2007) and milk production (Tousova et al., 2014; Rotz et al., 2003). Technical
efficiency identifies the effectiveness with which given inputs are used to produce an output. (EconomicsHelp, 2016)

As stated before, the technical efficiency identifies how efficient the inputs are used to produce an output. In the research of Steeneveld et al. (2012) the output was the total farm revenues. In total farm revenues the efficiency of the whole farm is displayed in one final number, where number 1 expresses farms to be most efficient and 0 is least efficient. All the inputs are included in this number e.g. no. of cows, land use, capital costs, labor costs and materials costs as well as all the revenues. Using this measure to indicate the performance of the AMS on a farm is undesired because it does not indicate the direct performance of the AMS, it measures the performance of the farm. The same applies when using profitability and technical efficiency as a measure of performance of the AMS. Therefore this research will focus on milk yield as a measure of performance of the AMS, especially on which factors are influencing this performance and what can be done to increase performance.

2.2 Focus of research

The aim of the research is to find out more about which management aspects have an influence on the efficiency of the AMS and how these aspects can be changed to improve efficiency. The milk yield per minute per box time will be used as a measure to find out which management practices have an effect on the AMS efficiency.

In previous studies different factors where already identified to influence the efficiency of the AMS such as the farmer, characteristics of the farm and the characteristics of the AMS present on the farm. Determinants of the character of the farmer are: degree of motivation in dairy farming, proactive behavior (e.g. monitor cows, check that udders and boxes are clean), the interest in and therefore the use of technology (Hansen, 2015), knowledge about technology/computers and management skills. The characteristics of the farm which influence the efficiency of AMS are farm size (Rotz et al., 2003), pasture availability (Spörndly and Wredle, 2005) and cow traffic (Svennersten-Sjauna and Pettersson, 2008). Lastly the AMS present on the farm influences the efficiency of the AMS, factors already found that have an influence are the perceived usefulness (PU), perceived ease of use (PEOU) (Davis, 1989) and sufficient guidance and support during implementation and after (Steeneveld et al., 2012). In chapter 5 the theoretical framework is elaborated on all the factors influencing efficiency of the AMS.
3. Research design

3.1 Definition of the problem

As stated before economic benefits, technical efficiency and work time between CMS and AMS did not differ according to recent studies. Nevertheless these were the most important reasons for farmers to invest in AMS (Steeneveld et al., 2015; Hogeveen et al., 2004). However there are contradicting studies which show that these benefits do appear when implementing the AMS in certain farms (Jacobs and Siegford, 2012).

Several studies expected that the main reason why AMS does not deliver the expected advantages is due to the poor management routines, poor visits to the AMS of the cows and to some extent technical issues in the AMS (Hansen, 2015; Jacobs et al., 2012; Svennersten-Sjaunja and Pettersson, 2008). Svennersten-Sjaunja and Pettersson (2008) state that with the proper management the functioning of the AMS could be at least as good as a CMS. This study looks at what differences in management practices there are between different AMS farms are and if there is a possibility to change to improve the perceived advantages from the system.

3.2 Research questions

The factors which are identified to have an influence on the performance of the AMS are placed in a conceptual framework (figure 2). To determine the research questions this framework was used. The main research question (MRQ) is: Which different management practices are currently used at AMS farms and how can these be changed to improve the efficiency of the AMS system?

- Sub question 1: What factors of farmer, farm or AMS characteristics can be found in literature which influence the performance of the AMS?
- Sub question 2: Which functions does the AMS used by farmers in this study contain and how can they be used?
- Sub question 3: What farm related factors are of influence on the efficiency of the AMS?
- Sub question 4: What farmer related factors are of influence on the efficiency of the AMS?
- Sub question 5: What AMS related factors are of influence on the efficiency of the AMS?
- Sub question 6: What can be changed by the farmer or producer of the AMS to improve performance of the system?

3.3 Research framework

This research consisted of four phases; the theoretical phase, the empirical phase, the analytical phase and the conclusion phase. In the theoretical phase the theoretical framework was set-up to answer sub question 1, an extensive literature review was conducted on factors of farmer, farm or AMS characteristics which influence the performance of an AMS on the farm.

Subsequently in the empirical phase, data collection started interviews were organized with Lely to answer sub question 2 and farm visits took place to collect data for sub question 3, 4 and 5 where interviews and observations were conducted. These collected data will be analyzed in the analytical phase. After that the conclusion and recommendations were written and given to Lely and the cooperating farmers. The research framework is displayed in figure 3. Data collection methods and analysis methods are described in the next section.
3.4 Methods

In this section the methods used to collect and analyze the data will be discussed.

3.4.1 Data collection

For this research contact was made with Lely, an international company operating in the agricultural sector. They develop technology that offers solutions for farmers and help them to excel in sustainable forage harvesting, milk production and energy sourcing (Lely¹, 2016). Data collection in the empirical phase of the research consisted of observations and interviews. An interview was organized with Lely, to identify their selling procedures, to get to know the AMS the farmers use and what support Lely gives to farmers to be able to work efficiently with the AMS.

Subsequently, 15 farms selected from a list of 73 farms were visited, who use an AMS of Lely. On farms observations and interviews were conducted to collect the necessary data. The 73 farmers were selected by using a judgmental sampling design (Kumar, 2011). Lely selected farmers which they knew were interested in time registration, efficiency management and research. By using this design the researcher was able to select farmers who can provide the best information to achieve the objectives of the study (Kumar, 2011). Thereby Lely provided the researcher with information about number of AMS present on the farms.
the farm, milk yield per minute per box time. The researcher selected 15 farms for the research. Five farmers with the lowest milk yield per minute, five farmers with average milk yield per minute and five farmers with the highest milk yield per minute. And as stated earlier milk yield per minute was chosen as a number to select because research found that this was positively related with milk production (Tremblay et al., 2016). Finally in this research in total fourteen farms where visited and fourteen farmers where interviewed and observed. The fifteenth farmer canceled the meeting at the last moment and another appointment could not be arranged. However the farmer did fill in the interview and his customer journey, so some of his results could be used. The supervisors of Wageningen UR had insight in the project archive and the obtained data, because this data is considered confidential it is not included in the report.

3.4.1.1 Observations

The farmers were observed in the morning, from the time the farmer started working until their breakfast or coffee time. The customer journey map was used to observe, with this method the journey of a customer before, during and after the purchase of a product can be visualized (Nenonen et al., 2008). The customer journey is designed to help organizations, such as Lely, to understand how customers use different channels and touch points, how they perceive the organization at each touch point and how they would like the experience to be. This knowledge can be used by Lely to improve the experience. However in this research we are interested in the performance of the AMS, so the customer journey will be evaluating experience of the farmer regarding the AMS instead of the experience with the organization. When the customer journeys of all visited farms are mapped, differences in these journeys can be identified and therefore factors of influence on the current use of the AMS can be identified (Nenonen et al., 2008). An example of the customer journey can be found in appendix 2.1 and 2.2. After the observations, interviews will be held with the farmers to be able to draw a conclusion on thoughts, opinions and personal experiences with the AMS.

3.4.1.2 Interviews

The choice for an interview with producer Lely is because this way more in depth answers can be derived compared to a questionnaire. Questions can be explained while the interview is going on so there is a smaller chance that questions will be misunderstood by the person who is interviewed (Kumar, 2011). Since it is important to understand all the functions of the AMS and there is no pre-obtained knowledge about these functions, the interview with Lely is a semi-structured interview so questions can be asked as they rise but a certain set of question can be prepared on beforehand (Kumar, 2011).
The interviews with the farmers will however be structured interviews to make the results comparable (Kumar, 2011). Farmers with the highest milk production per minute are identified as most efficient. Farmers with the opposite results will be identified as least efficient. The observations conducted on the farms can be used to identify the differences in management between efficient and less efficient farms. The researcher used audio taping to record the interviews with the farmers.

3.4.1.2.1 Interview questions

The interview used on the farm visits was composed by the researcher (see appendix 1). Since the farmers should be able to speak about their farm and experiences in their own words the interview was held in Dutch. This was meant to make it easier for the researcher to elaborate on questions and it was meant to make the farmer feel more comfortable and explain their answers clearly.

The interview consisted of different parts because different subjects were covered in table 1 an overview is given. The different subjects and the reasons of inclusion of these subjects are described below.

Table 1 Overview of subjects in interview

<table>
<thead>
<tr>
<th>Parts</th>
<th>Questions</th>
<th>Subject</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1-14</td>
<td>Farm characteristics</td>
</tr>
<tr>
<td>2</td>
<td>15-24</td>
<td>Technology on farm and use of AMS in practice</td>
</tr>
<tr>
<td>3</td>
<td>25-33</td>
<td>Perceived performance AMS</td>
</tr>
<tr>
<td>4</td>
<td>34-41</td>
<td>Farmer’s characteristics</td>
</tr>
</tbody>
</table>

Farm characteristics

The questions about the characteristics of the company are included to make the interview and customer journey’s comparable and to create a picture of the company and its existence. As mentioned before company characteristics like cow traffic, access to pasture and size of the farm have already been proven to have an effect on the performance of the AMS. All these concepts are further explained in chapter 5.

Technology on farm and use of AMS in practice

These questions are set-up to determine which technology the farmer and therefore to see which data he can access. This information was used to compare with the data derived from observations in combination with a few questions answered in this part of the
interview, to see which data is actually used by farmers. Furthermore there was determined what the perceived ease of use and the perceived usefulness of the product is.

**Perceived performance AMS**
Since recent studies stated that the expected advantages perceived when implementing an AMS are not always experienced by the farmers it is interesting to know if this is the case with these farmers. This enables the researcher to see which farmers do or do not experience advantages of the AMS and what is a possible cause of this.

**Farmer’s characteristics**
As mentioned earlier previous research stated that characteristics of the farmer are also very important while assessing the performance of the AMS. Several characteristics are investigated in this interview; interest in technology, knowledge about technology, proactive behavior in the farm and motivation in farming.

### 3.4.2 Data analysis
In this section the methods used to analyze the collected data are discussed. Firstly the analysis of the interviews and secondly the analysis of the observations.

#### 3.4.2.1 Interviews
The interviews with the farmers were analyzed using excel. This analysis after data collection of the data consists of five steps (Schutt, 2014):

1. Documentation of the data
2. Organize and categorize the data into concepts (coding/indexing)
3. Search for connections and influences these different concepts have on each other
4. Evaluation on validity of conclusions
5. Reporting the findings

The documentation of the data consisted of transcription from audiotapes and notes. In this way the obtained information was saved as a whole and easier to interpret by the researcher. The organizing and categorizing step consists of identifying concepts in the transcripts for example because the concept is repeated, surprising, stated as important or previous knowledge of the concept in scientific articles is available. Resulting from this step are different kind of concepts which appeared to be relevant for the farmers and Lely. Subsequently connections between the different concepts will be examined and explained by the researcher. In the fourth step an evaluation about validity of the conclusions will be done, in the discussion part of the thesis. And in the last step findings will be reported, this
can be found in the results chapter of the report (Schutt, 2015; Walliman, 2006; Bryman, 2004).

3.4.2.2 Observations

By creating the customer journey maps the analysis method will just be to compare the different journeys and conclude on the differences. Combining these with the other results hopefully a conclusion can be drawn about a recommended way of use of the AMS within the farm which will optimize the results.
4. Theoretical framework

As stated before several aspects are influencing the performance of the AMS on farms. In this chapter all the factors influencing AMS performance which are mentioned in literature are explained. Subsequently there is elaborated on the way each factor influences the AMS performance.

4.1 Farmer Characteristics

One of the farmer characteristics that is identified to influence the performance of the AMS on the farm is motivation in farming (Hansen, 2015). In the research of Hansen (2015) it has been stated that motivation is gathered when discussing problems and new ideas with other farmers within a farmers’ network. The farmers interviewed in the study of Hansen (2015) clearly stated that their network and the openness to discuss problems and ideas, according to them was very important to develop expertise, get new ideas, get inspiration and motivate them and contributed to the performance of the AMS. Several other studies state that motivation is essential to reach managerial efficiency, because it affects learning results positively and advances application into practice of the acquired knowledge (Rougoor et al., 1998; Trip et al., 2002; Palmer, 2005).

Another characteristic found important for a farmer to optimize the performance of the AMS is proactive behavior. In this case a farmer with proactive behavior means he or she is adapting the technology to their needs, monitoring individual cows and getting familiar with the herd management system (Hansen, 2015). When the AMS is adapted to the farmer’s needs, which means that they set which alarms they want to receive and when, this might prevent the farmer feeling that they are constantly on call after implementation of AMS.

Subsequently the knowledge and thereby the use of technology is an important factor which has an influence on the performance of the AMS. Regarding data usage Inmon (2005) identified four types of different end user of a data warehouse: ‘farmers’, explorers, miners and tourists. A data warehouse in this case is a store of date obtained from the AMS and used to guide management decisions. These different types of end users identify the way different farmers use data obtained from the AMS. A ‘farmer’ uses the AMS data regularly, it is often the same data and used on a routine basis. Therefore it makes this user type predictable and does not take risks. He or she knows what data is needed to get the preferred information and as a result he or she will never discover new options but always obtains the needed information (Inmon, 2001; Inmon, 2005).
The tourist user type uses lots of AMS data. They discover data randomly and knows where to find all information, while discovering they sometimes stumble onto useful information. The knowledge they have is more often a breadth of knowledge, as opposed to a depth of knowledge (Inmon, 2001; Inmon, 2005).

An explorer has characteristics from a farmer as well as from the tourist. The explorer is a very unpredictable person in using data of AMS. They do not know what they are looking for and look over an enormous amount of data. Therefore often finds data which is not very useful but occasionally he or she finds very useful information. Also the explorer looks at relations between data instead of the data itself (Inmon, 2001; Inmon, 2005).

Lastly the miner digs into data and is a statistician. He or she determines the validity and strength of the acquired data. Often collaborates with an explorer user type, where the explorer obtains data and relationships and the miner tests them and sees if the data can be underpinned (Inmon, 2001; Inmon, 2005).

The knowledge about and interest in specific data will certainly specify which type of user a farmer became. The level of knowledge about the technology itself effects the degree of efficiency positively (Kislev and Shchori-Bachrach, 1973). So more knowledge is positively related to a greater efficiency.

The term management skills in this case refers to the maturity of the farm environment, so whether or not the farmer understands which requirements are necessary and which actions need to be executed to realize remarkable functioning of processes and therefore optimal use of the AMS (Chua and Wong, 2011; Hyötläinen, 2013; Kerremans, 2008). Maturity of the farm environment affects the readiness of the farm to implement new technologies for improving business performance. These technologies are sometimes referred to as business intelligence (BI) applications. In Gartner’s Business Process Management (BPM) maturity and adoption model six phases of maturity are distinguished they are displayed in the figure below (Melenovsky and Sinur, 2006).
This maturity model can help a farm to get ready for the implementation (Chuah and Wong, 2011) of an AMS by identifying in which phase the farm environment is and subsequently working on improving the maturity. Concluding if a farm is in the last stage of maturity, and thereby well process managed, the implementation of a new BI application (e.g. AMS) is likely to be successful (Hyötläinen, 2013).

4.2 Farm Characteristics

Different farm characteristics have been proven to influence the efficiency of the AMS in a farm. Such as availability of pasture, cow traffic system used and farm size.

4.2.1 Pasture availability

The availability of pasture effects the milking frequency, according to Spörndly & Wredle (2002) the milking frequency was generally 0.2-0.3 milking/day lower when cows had access to pasture. The milk frequency of the cow has an effect on the milk production per cow, therefore to influence the performance of the AMS positively, it is preferable to have a high milking frequency (van Dooren et al., 2002). However the results on whether providing pasture and the way of providing pasture has an effect on milk production, milk frequency and grazing behavior are very contradicting.
### 4.2.1.1 Grazing systems

The first factors which seems to have an effect on the motivation of the cows to visit the AMS is the grazing system. First of all systems can be divided in restricted grazing, unrestricted grazing, summer barn feeding and summerfeeding (Remmelink et al., 2016). In restricted grazing systems cows are only allowed on to the pasture for a restricted amount of time. Whereas in an unrestricted grazing system the cows are allowed to be on the pasture whenever they want. Lastly in summer barn feeding and summerfeeding the cows do not have access to pasture, the difference is that in summer barn feeding the cows get freshly mowed grass when it is available whereas in summerfeeding cows are fed with silage (Remmelink et al., 2016).

Three grazing systems can be distinguished and used within restricted and unrestricted grazing: strip grazing, continuous grazing and rotational grazing (van Dooren et al., 2002). Strip grazing is a system where the cows get a new area to graze each day, without the possibility to graze on the area that was used on the day before (Remmelink et al., 2016). Continuous grazing is a system where the grazing takes place in one area during the whole season. In rotational grazing the cows graze on each pasture for a number of days (van Dooren et al., 2002; Remmelink et al., 2016). There exist different variations of rotational grazing used by Dutch farmers for example ‘omweiden’ where the cows are on a piece of the pasture for a couple of days and then they move on to the next one, ‘standweiden’ where the cows are on a piece of the pasture for at least three weeks and then move on to the next one (Remmelink et al., 2016; Stichting Weidegang, 2016).

### 4.2.1.2 Effects of grazing

Using different types of grazing management in a farm effects the performance of the AMS in several ways.

#### 4.2.1.2.1 Distance

The first one discussed is the distance between the stable and the pasture. In the research by van Dooren et al. (2002) was found that the milking frequency decreased by 0.18 milkings/day per kilometer for farms with free cow traffic. However the milk production did not decrease when the distance increased between barn and pasture in this research. Subsequently the effect of distance on milk production, milk frequency and milk interval was not always found in researches. In the research of Ketelaar- de Lauwere et al. (2000) showed that distances to pasture up to 360 meter did not affect the visits of the cow to the AMS. In this research the farmer used strip grazing and cows where allowed to spend up to 15 hours on the pasture daily. In another research of van Dooren et al. (2004) where two distances from pasture to barn were compared the one was less than 150 meter and the other was more than 500 m, no differences in milk yield or milking interval were found.
However a research that investigated the difference in milk yield and milk frequency of cows grazing in a near pasture (50 meter) and cows grazing in a distant pasture (260 meter), differences have been found (Spöndly&Wredle, 2004). Cows in the near pasture had a higher milk yield and frequency (29.1 kg and 2.5 milking/day, respectively), than cows grazing in the distant pasture (26.4 kg and 2.3 milking/day). So these results are very contradicting however it is known that a consistent and regular milk interval and milk frequency of the cows when using an AMS is essential for optimizing milk production per cow (Lyons et al., 2014).

Ketelaar- de Lauwere et al. (2000) also found that sward height of the pasture has an effect on milk frequency. When sward height decreases the number AMS visits increased from 4.4 to 7.3 and the milk frequency increased from 2.6 to 3.0. However they stated that this might also have something to do with the weather conditions.

4.2.1.2.2 Grazing systems

The earlier discussed grazing systems were investigated and found to have an effect. It seemed that farmers who used strip grazing had the lowest number of fetchings (van Dooren et al., 2002). Whereas farmers who used siesta grazing had the highest amount of fetchings. After strip grazing, continuous grazing had the lowest amount of fetchings and thereafter came rotational grazing (van Dooren et al., 2002). A higher amount of fetchings means that the milk intervals are more irregular and milk production is not optimal, therefore the systems with the lowest amount of fetchings are preferred.

4.2.1.2.3 Time in pasture

Kennedy et al. (2009) conducted a research investigating the effect of restricted access time to pasture on milk production, grazing behavior and dry matter intake. Four treatments were tested; (1) full-time access, (2) 9 hour access, (3) two periods of 4.5 hours access after both milking and (4) two 3 hour periods after both milking. In milk production no differences were found, however in other researches (Mattiauda et al., 2003; Pérez-Ramírez et al., 2008) differences in milk production were found. In the research of Kennedy et al. (2009) the minimum pasture access time was six hours. The two researches mentioned before decreased access time from eight hours until four hours per day. So giving cows access time to the pasture like done in researches of Mattiauda et al. (2003) and Pérez-Ramírez et al. (2008) might be too limitary.

Although Kennedy et al. did not report a change in milk production when restricting access to the pasture, a change in grazing efficiency was found. The cows who had restricted access to pasture (treatment 2,3 and 4) increased their grazing efficiency (dry matter
intake/ minute and dry matter intake / bite) and spend more time grazing than the cows having full-time access to the pasture, which Pérez-Ramírez et al. (2008) also found.

4.2.2 Cow traffic

Cow traffic refers to a series of gates placed in the farm which forces cows to walk a certain pattern (Jacobs and Siegford, 2012). In barns three different types of cow traffic can be implemented; ‘forced’ traffic, ‘controlled’ traffic and ‘free’ traffic (Melin et al., 2007). In a ‘forced’ cow traffic system the cows have to pass through the AMS to get to the feeding area, and from the feeding area to the lying area there is a one-way gate which prevents the cows from moving in the opposite direction. So cows can only move in one-way to feed, lie down and be milked. In a ‘controlled’ traffic system, also known as ‘semi-forced’ traffic or ‘guided’ traffic, selection gates are used to assess if cows have expired their milk interval time. If so, they will be guided to the AMS before visiting the feeding area, otherwise they can visit the feeding area directly. ‘Free’ cow AND production AND AMS traffic systems enables the cow to move between the freely between the feeding and resting area and the AMS (Jacobs and Siegford, 2012).

Tremblay et al. (2016) identified that a ‘free’ cow traffic system positively affected the milk production positively. In the research of Jacobs and Siegford (2012) is stated that in a ‘forced’ cow traffic system the number of visits was higher compared to ‘free’ cow traffic. However there was no difference found in successful milking frequency, which was in line with previous conducted researches on that subject (Hermans et al., 2003; Munksgaard et al., 2011). Tremblay et al. (2016) nevertheless found that when the average number of nonmilking visits increases, milk production decreases. According to them milk production in ‘forced’ cow traffic systems are affected because of the decrease of feed consumed by the cow, time spent eating and number of times visited the feed bunk (Ketelaar-de Lauwere et al., 2000; Melin et al., 2007).

4.2.3 Farm size

While implementing the robots thought should be given to the herd size and number of robots to increase AMS performance and net returns (Rotz et al., 2003). Since it has been proven that number of cows per robot and number of robots per pen has an effect on milk production (Tremblay et al., 2016). The number of cows per robot has an effect on the milk production, as box time and milkings per cow per day decrease to 6.1 and 2 respectively the increase of number of cow per robot has a negative effect on milk production (Tremblay et al., 2016) (figure 5). Thereby having two robots per pen instead of one was associated with a higher milk production per robot per day (Tremblay et al., 2016). A possible explanation for this finding
is that when two robots are available in one pen, the low ranked cows have more opportunity to be milked. These cows have been shown to wait longer to use the robot than higher ranked cows (Keterlaar- de Lauwere et al., 1996; Melin et al., 2006).

![Graphs showing interactions between Boxtime (min.), Milkings (/cow/day), Milk production (kg) and Cows per robot (Tremblay et al., 2016)](image)

4.3 The AMS

Lastly the characteristics of the AMS present on the farm and the service that comes with it influences overall performance. Three factors have been mentioned to affect the performance of the AMS; support by the supplier and the perceived usefulness and ease to use of the system. These factors will be discussed below.
4.3.1 Ease to use and perceived usefulness

That perceived ease of use (PEOU) and perceived usefulness (PU) affects the usage and acceptance of technology is proposed by the Technology Acceptance Model (TAM) (Davis, 1989). Flett et al. (2004) confirmed that PU and PEOU are determining user acceptance and usage behaviors of technology, which is in line with earlier found results (Brosnan, 1999). Therefore ease of use and usefulness are identified to be characteristics of the AMS which influence the use.

4.3.2 Instructions and support by supplier

In the research of Steeneveld et al. (2015) where the economic consequences of investing in sensor systems on dairy farms where improving technical performance was investigated. Providing guidance and support on the usage of the output was considered an option to improve performance of the AMS and attached sensors.
5. Results

The results of the research will be displayed in the following chapter. To give a clear overview of the functions and options the AMS used by the farmers has, these will be presented in the first section in this chapter. Subsequently a part of Lely’s advice document for farmers, on how to use and implement the AMS and the management routines will be explained and lastly the results of the observations (customer journeys) and interviews will be presented.

5.1 Astronaut A4 function description

To find out which data a farmer uses from the AMS system an overview is presented of the data that is currently available for the farmers in this study, this overview is given in the next sections. This overview makes it possible to see which data was really available for the farmers and which data they actually used so conclusions can be drawn about the usage of the system.

5.1.1 The AMS

The complete automatic milking system delivered by Lely consists of four primary parts: the milking robot(s), the milk storage tank, the control system and the compressor. The milking robot itself consists of two primary parts: a central unit (which supplies water, power, cleaning solutions and regulates compressed air and applies vacuum) and the robot units (where the cows are milked). The milk storage tank stores the milk obtained from the cow and the control system of the robot is used to manage and control the milking system and it has been provided with three user interfaces:

- E-Link to control the robot
- CRS+ user interface is a cleaning synchronization and remote alarm system, which e.g. schedules cleanings for attached robot units, enables emptying the milk storage tank and sends alarms to the farmer.
- T4C farm management software to manage the herd, the milking system and all other connected devices.

The last primary part of the AMS is the compressor, it is necessary for cleaning the milk lines to for example the milk storage tank.

As stated earlier the milking robot consists of two parts the central unit and the robot unit. And these can be controlled by using the different user interfaces. In figure 5 can be seen how the robot units and the central unit are connected to the different user interfaces and the milk tank. The robot units, central unit and the CRS+ are connected to the T4C management software. Therefore the T4C management software program is able to collect
and process data from these sources. The third user interface which is not displayed in figure 5 is E-link. E-link is the software on the robot and communicates with T4C, thereby it controls and monitors the robot unit. The T4C management software makes the collected data visible and translates data to attentions and usable information for the farmer (Lely², 2016).

Figure 6 Connections between robot unit, central unit, computer and milk tank.

5.1.2 Robot unit

The robot unit has five major processes: the milking process, milk transport, milk quality control, feeding and cleaning. In the milking process the cow comes into the robot and is detected by the 3D camera which detects the position of the cow, guides the robot arm and keeps the gates closed when desired. Subsequently the cow is identified and the robot unit verifies whether the cow needs to be milked. If so, the robot arm will be positioned underneath the cow and pre-treatment (brushes clean and massage the teat) is conducted, afterwards the teat cups are placed on the teats and the cow is being milked. After the milking, if the robot unit has a weighing platform, the cow’s weight is measured. When milk is being transported to the milk tank or M4Use, it goes through the robot arm where the Milk Quality Control version 2 (MQC-2) is installed. Here it collects data concerning the milk quality (i.e. milk flow, milk color, milk conductivity, milk temperature and air flow). After the milk is transported to the milk tank, the cleaning routine of the robot is set in motion. What routine the robot performs depends on the cleaning solutions installed and
whether the milk of the cow was separated from the tank or not. Furthermore the robot should be cleaned by the farmer on a day-to-day basis to improve performance. During the milking process the cows are also being fed concentrates. The amount of different types of feed that can be fed in the robot unit is determined by which version of the Astronaut A4 the farmer has, more information about these versions is given in the next paragraph.

**Versions of Astronaut A4**

The Astronaut A4 comes two different versions either the Manager version or the Operator version. The differences between these versions are displayed in table 2.

**Table 2 Differences between Operator and Manager version of Astronaut A4 (Lely³, 2016). X= Not available | O= Optional | S= Standard. ✗ not available in all countries.**

<table>
<thead>
<tr>
<th>Astronaut A4</th>
<th>Operator</th>
<th>Manager</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk unit</td>
<td>S</td>
<td>S</td>
<td>Milk unit of stainless steel, 3,1 mm thick</td>
</tr>
<tr>
<td>Gravitor weighing platform</td>
<td>O</td>
<td>O</td>
<td>The accurate and stable weighing platform gives information about the well-being of the cows</td>
</tr>
<tr>
<td>One type of feed</td>
<td>S</td>
<td>S</td>
<td>Concentrate dispenser for one type of concentrate</td>
</tr>
<tr>
<td>Two types of feed</td>
<td>O</td>
<td>O</td>
<td>Extra dispenser for second type of feed</td>
</tr>
<tr>
<td>Three types of feed</td>
<td>X</td>
<td>O</td>
<td>Extra dispenser for third type of feed</td>
</tr>
<tr>
<td>Four types of feed</td>
<td>X</td>
<td>O</td>
<td>Extra dispenser for fourth type of feed</td>
</tr>
<tr>
<td>Titania</td>
<td>X</td>
<td>O</td>
<td>Liquid dispenser in the manger</td>
</tr>
<tr>
<td>MQC-2</td>
<td>S</td>
<td>S</td>
<td>Milk quality control (i.e. milk flow, color, conductivity, temperature, air flow)</td>
</tr>
<tr>
<td>MQC-C</td>
<td>O</td>
<td>O</td>
<td>Measures and displays somatic cell count for every individual cow</td>
</tr>
<tr>
<td>Pura steam cleaning</td>
<td>O</td>
<td>O</td>
<td>Cleans teat cups after every milking with hot steam (150 °C)</td>
</tr>
<tr>
<td>Buffer cleaning system</td>
<td>O</td>
<td>O</td>
<td>Reserve supply of cleaning chemicals for one day.</td>
</tr>
<tr>
<td>E-link</td>
<td>S</td>
<td>S</td>
<td>In Operator only robot unit can be controlled. In Manager also T4C management software can be displayed.</td>
</tr>
</tbody>
</table>
When an Astronaut A4 is bought by a farmer at this moment, these are the options they get offered however in the last years Lely changed the optional and standard options on the different versions, so options of farmers might differ depending on the year they implemented the Astronaut A4. Below we listed the possible data that can be collected by the Astronaut A4 depending on which version is installed in the farm:

- Milk color per quarter
- Fat and protein content
- Lactose content in milk
- Conductivity per quarter.
- Temperature of the milk.
- Somatic cell count per cow per milking.
- Weight of the cow.
- Milk production.
- Feed intake.
- Residual feed.
- Milking time.
- Milking speed.
- Number of milkings.
- Number of refusals.

### 5.1.3 Other data collected

When other devices are connected to the AMS, more data can be collected about the herd. For example the activity of the cow, when using the Lely Qwes, amount of roughage per production group and feed efficiency when using the Lely Vector. In the figure in Appendix 2 every technology possible to implement which delivers data to the T4C management software is displayed.

### 5.2 Functions of the AMS

Visualizing the functions and data availability for the farmer like this enables and eases the identifications of the functions and data most used by the farmer, later in this chapter.

In the last paragraph the robot unit was identified to have five major processes and the whole system has three user interfaces. The main user interface is T4C management software, because the robot unit is connected to T4C with E-link and CRS+ also reports to
the T4C management software about robot performance. In table 3 different functions are categorized there is shown which data is collected by each category.

**Table 3 Available functions and collected data. * Optional when purchasing the system.**

<table>
<thead>
<tr>
<th>Name of function</th>
<th>Description of function</th>
<th>Data collected by technology</th>
<th>Technology used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>Before all other functions can start, the cow is identified in the robot. Which activates the milking, feeding and collects data about activity</td>
<td>• Activity of the cow • Rumination minutes*</td>
<td>T4C</td>
</tr>
<tr>
<td>Milking</td>
<td>Cow is being milked in the robot, weighed and MQC.</td>
<td>• Weight of the cow* • Milk flow • Milk color • Milk conductivity • Milk temperature • Air flow • Somatic Cell Count* • Milking time/ dead milking time • Milking speed • Number of milkings • Number of refusals</td>
<td>Robot Unit</td>
</tr>
<tr>
<td>Transport</td>
<td>Milk is being transported from the milk jar in the robot, it passes the filter, to the milk tank.</td>
<td>• Replaced filter</td>
<td>CRS+</td>
</tr>
<tr>
<td>Feeding</td>
<td>As the cow enters the robot it will receive concentrates, if it is allowed to.</td>
<td>• Feed intake • Rest feed</td>
<td>E-link</td>
</tr>
<tr>
<td>Cleaning</td>
<td>Appropriate cleaning solution is conducted.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
All the data collected while the different functions of the AMS are conducted is eventually sent to the T4C system where it is transferred in usable numbers and data for the farmer.

5.3 Factors of influence on current efficiency level

This paragraph is dedicated to the different routines the 14 farmers had in different farms and which of this routines are likely to affect the efficiency of the AMS. The results of the research retrieved by observing and interviewing on different farms will be presented in the following sections.

5.3.1 Effects of farmer characteristics

Firstly we looked if we could identify the farmers to have different user profiles. Using the questions from the interviews and the customer journeys we found that there seemed no effect that farms who have a higher milk yield per minute use more data (figure 7). However it can be seen that only a two farmers use 70% or more of the available data. The most farmers used between 53% and 64%.

![Effect of data usage on milk yield per minute](image)

*Figure 7 Effect of data usage on milk yield per minute in robot*

Interesting is that the interviews three of the five farmers with high milk yield per minute stated: they knew how to use necessary options and where to find them. But they also spend time once every month or week to discover more useful options of the system. Farmers in the other groups, according to the observations and interviews, mainly used the same options of the system. The farmers were also asked whether they spend a lot of time on discovering the options of the system. Based on this question and statements in the interviews was found that most farmers had a ‘farmer’ user profile and used the same amount of data every day. Only a few were explorers and tourists. No clear differences
were found between the different milk yield groups and data user profiles. The figure is displayed in appendix 3.

The maturity of the farm environment displays whether the farmer’s management skills and the business is mature enough for the implementation of a new technology. It was striking that the five farmers with high milk yield per minute identified their management and business environment as ‘optimizing business processes to gain maximum revenues’, which relates to the highest phase of maturity in Gartner’s maturity model. The farmers in the other two groups had more inconsistent results, where two of the low milk yield per minute group identified their skills and environment to be very mature as well, as others stated to be busy ‘standardizing business processes’.

The motivation of farmers is affected by the amount of people that farmers regularly discuss farming, ideas about farm farming or problems on the farm with. In the figure 8 can be seen that only farms with a low milk yield per minute did not have regular discussion partners at all. While most of the farmers with a high milk yield per minute had more than 5 regular discussion partners.

The effect of proactive behavior was tested by asking the farmer about their behavior concerning the cows and the program, these answers where ranked from not proactive to very proactive. In figure 9 milk yield per minute and proactive behavior are displayed. Most farmers conducted mostly proactive behavior. Only farms in the group with a high milk yield where identified to be very proactive. Most of the farms that where identified to lack
proactivity were in the low milk yield group, a few were in the average milk yield group and none were in the high milk yield group.

The last farmer characteristic is knowledge. There are no clear effects found between the level knowledge farmers thought to have about on-farm technology and the milk yield per minute. Most farmers (see figure 14 in appendix 3) thought their knowledge was up to date.

5.3.2 Effects of farm characteristics

Regarding farm characteristics we tested whether farm size, age of the barn, number of robots, production groups, cow traffic and access to pasture had an effect on the milk yield per box time (L/min). Only pasture availability might have an effect. The five farms with a high milk yield per box time (L/min) (> 1,78) and an average milk yield per box time (L/min)(1,59 -1,63) didn’t have pasture availability. While farms with a low milk yield per box time (L/min) (>1,52) more often did have pasture available for the cows (figure 7).
Figure 10 Milk yield per minute and pasture availability in 15 farms

The number of AMS available on farms did not clearly show to have an effect on the milk yield per minute. Only two farms had one AMS (see figure 14 in appendix 3). One had a high milk yield and one average. Half of the farms had three robots and the biggest group had a low milk yield per minute. Also for the factors cow traffic and production groups we could not find an effect. For cow traffic because all farms had free cow traffic so effects of differences between cow traffic systems could not be investigated. Furthermore only six farms had production groups and they were evenly divided over the milk yield groups. In figure 15 in appendix 3 can be seen that most likely the barn age did not have any effect on the milk yield per minute. Results are very spread and therefore no effects can be found.

5.3.3 Effects of AMS characteristics

For AMS characteristics we investigated whether the perceived usefulness, perceived ease of use and if the instructions and help from the supplier had effect on the milk yield per minute. Regarding perceived ease of use we asked farmers if they find the T4C management system easy to use. Most of the people in the group with the high milking time said the system was relatively easy to use. In elaboration to that one farmer stated that the data could have been more compact and clear, two said that it was easy to use once figured out what data is useful for them, however the discovering/setting of new options (e.g. extra attention lists) for daily use was considered difficult. Because this is not a daily task and therefore farmers have a hard time finding these new functions and options. One farmer from the low milk yield group also said it was difficult to obtain new graphs and analyses from the program. The other farmers in that group said it was fairly easy to use, once you know where and how to find data you need. In the average milk yield group two farmers said it was not easy to use, one of them often still used Agrovision in his management routine. The other three indicated that the program was very easy to use.
Subsequently the perceived usefulness was determined for each farm by counting the use of different functions in the management system. A function was considered to be different from the previous or next one when another list in T4C (e.g. udder health, collect cows, activity) or another function in T4C (e.g. cows to separate or change concentrate settings for cows) was used on the computer. When a farmer used the same function or option twice this counted as one. There was no difference found between usage in farms with a high milk yield and farms with lower milk yields (see figure 16 in appendix 3).

Lastly we look if the help and instructions received from the supplier during implementation could have an effect on the milk yield. Before discussing the results from the interviews and observations, we present the advice Lely gives farmers, in the brochure: ‘Robotic Farm Management’, about routines which should be conducted, daily, weekly and monthly to provide clarity to the farmers and enables them to do their work well and efficient.

**Lely’s Advice**

Changing from a CMS to an AMS requires revision of all management routines, in comparison to CMS more time is spent in the stable and working at the computer when using AMS. Using the computer to obtain Information is most likely new for most farmers, because much more data is obtained by the robot to inform the farmer. Which is not the case when using a CMS. Therefore in Lely’s brochure: ‘Robotic Farm Management’ an advice is given about how often a farmer should use the data on the computer and what for. Firstly they state that a farmer should at least check T4C twice a day where they should firstly examine the KPI’s displayed on the Dashboard (Figure 11). Secondly they advise to examine which cows are late for milking and which of them have to be picked up, how many failed milkings occurred, check the udder health attention list in Favorite Reports (Figure 11) and monitor the performance of the robot unit (e.g. examine why milkings failed, refusals, dead milking time (DMT)). Subsequently they state that daily routines are important to reduce stress and create stability in farming, They are convinced that planning is the key to efficient labor. According to Lely when working with employees on a farm it helps to implement Standard Operating Procedures (SOP) or...
strategies and protocols to make sure every task on the farm is carried out and in a logic order, so time can be saved. In Appendix 2 an example of a SOP can be found.

![Figure 1. Home page](image)

**Figure 11 Home page of T4C (Lely³, 2016)**

**Effect of instructions and support**

In the low milk yield group two farmers stated that overall they received enough help and instructions from Lely, however they also stated that during implementation of the robots they experienced some difficulties and the farmers considered these problems to be caused by insufficient accompaniment from Lely during the implementation. Furthermore the third farmer in the low milk yield group stated the support and instructions given by the supplier was sufficient but he felt he still had to do a lot without their help. The last two farms in this group one stated the support and instructions where fine and had no complaints at all, and the other one said it was fine, however more was expected. The farmer thought that there would be supervision by Lely on the farm for the first three days, in reality they were present three hours after the robot was implemented and left before the night. In the group which had average milk yields, two farmers specifically expressed that help was sufficient, and that it mainly consisted of setting the management program and helping the first evening of implementation. The other farmers said that they were contempt with the support and instructions. In the group with the high milk yields one of the farms was a ‘zero series’ farm, this means they had the first version of a robot and therefore they
received a lot of support and Lely visited their farm very often to tackle problems together. Two other farmers in this group were satisfied with the amount of support they got and one said the support was good but he thought that the fact that he did preparation himself like the necessary subjects had a positive influence on the process of implementing and working with the robots. The last farmer in this group did not have sufficient support and instructions according to his opinion.
6. Discussion

All the effects mentioned in the theoretical framework and the results will be discussed here. Firstly the farmer characteristics will be discussed (i.e. motivation in farming, interest in technology, proactive behavior, knowledge, use of data and management skills), secondly the farm characteristics will be discussed (i.e. pasture availability, cow traffic and farm size) and lastly the AMS characteristics (i.e. functions of the AMS, PU, PEOU and instructions and support by the supplier).

In the results was mentioned that most of the farmers used between 53% and 64% of the available data. Two of the fifteen farms were excluded in this figure because they both checked the data they thought to use during their daily routines themselves in the interview, and this might have affected their results. Thereby we also see that only a few farmers explore the possible options of the systems every once in a while. Two farmers with a high milk yield per minute, who used 57% and 73% of the available data, also claimed to spend time to exploring the different options of the T4C management software. And two farmers in the other groups, one in the low milk yield group and the other one in the average milk yield group, also stated this. These farmers were identified as explorers, the biggest group of explorers consisted of farmers with a high milk yield. However a greater amount of farmers in the high milk yield group was identified to be a ‘farmer’ user type. Most farmers with lower milk yield per minute are identified to be a ‘farmer’ user type because some of them stated that they used the same data and attention lists every day. When sample size is increased, clear differences between data usage and user profiles might be discovered. However it very interesting to know overall farmers do not use all of the data and functions available and even though it cannot be proven that this has an effect in this study it would be interesting to look further into this effect. Especially because as several studies expected (Hansen, 2015; Jacobs and Siegford, 2012) we now know that farmers use data differently and there exist different user profiles.

Maturity of the management skills and the business environment seemed to have a positive effect on the milk yield. However in the average and low milk yield group results were more inconsistent. It might be the case that farmers who identify their business environment as mature, have more structural processes and therefore a higher milk yield. However this could not be identified with the customer journey observation method. All farmers overall more or less did the same tasks in the morning routine however it was the process of the decision-making and determining which tasks should be done, that the researcher noticed to be very different between milk yield groups. The researcher experienced that in farms with a low milk yield per minute, the routines were not as
structural as in the farmers with a high milk yield minute. And this could not be recorded in the customer journey, so if further research is conducted this should be taken into account.

Subsequently the number of discussion partners the farmers could have an effect on the milk yield per minute. Only farmers with a low milk yield per minute had no discussion partners at all. Farmers with average and high milk yield per minute all had more than one discussion partner. This would be in line with the results in the study of Hansen (2015), in which they identified that high motivation in dairy farming is needed to successfully use the AMS. Other studies state that motivation effects learning results and application of acquired knowledge into practice (Rougoor et al., 1998; Trip et al., 2002; Palmer, 2005). This could indicate that there is an effect between the amount of discussion partners and the height of the milk yield per minute. However there might be more factors influencing the farmers motivation which can also explain the differences in milk yield, this could be investigated in further research.

Another farmer characteristic identified to influence the milk yield per minute positively was proactive behavior (Hansen, 2015). The results show that farmers who achieve a high milk yield per minute always were somewhat proactive of higher. Only some farms with an average and low milk yield per minute where identified as not proactive. So differences between height of milk yield and proactive behavior can be seen in these results and it suggests that the findings are in line with the study of Hansen (2015).

In the results appeared that availability pasture might have an negative effect on milk yield per minute and therefore on the efficiency of the AMS. Which would be in line with the results of Spörndly & Wredle (2005). However in previous studies very contradicting results were found about the effects of distance to pasture and milking frequency (Ketelaar- de Lauwere et al., 2000; van Dooren et al., 2004; Spörndly & Wredle, 2004). Regarding restricted grazing we could not draw a conclusion because only five farmers had pasture available and all conducted restricted grazing. However we expected that no differences would be found, like in the research of Kennedy et al. (2009), because all the farmers conducted at least five hours of grazing or more, except for one farmer he gave four hours access per day. Which was not the case in the study of Mattiauda et al. (2003) and Pérez-Ramírez et al. (2008) where they did find differences in milk production. The cows in these studies where restricted to four hours or less access time to the pasture, which might have been to limited. So it would be expected that the farmer giving the cows access to the pasture only four hours a day was in the low milk yield group, nevertheless he was in the average milk yield group and the second best producing farm with pasture available.
Furthermore the number of robots on the farm did not seem to have an effect on the milk yield. While in other studies has been proven that having two robots per pen was associated with a greater milk production (Tremblay et al., 2016). They also identified that the number of cows could have a negative effect on milk production when box time decreases to 6.1 and milking frequency decreases to 2 times per cow per day. This might be why our results differ from the ones found in Tremblay et al. (2016), but we did not collect data regarding the number of cow per pen and per robot so we cannot draw a conclusion about this.

The last characteristics that could affect the milk yield per minute are the ones that have to do with the AMS itself. The farmers in the high milk yield group found the T4C management system easy to use, a few stated in addition that it is a challenge to find the new functions and options in the system. Overall the farmers said the system was easy to use, however it seemed that farmers in the low and average milk yield group had more trouble adapting because this was mentioned a few times in these groups. Which might also explain why farmers in the high milk yield group have more trouble discovering new options, because the farmers in the other groups might still be adapting or happy that they finally adapted and find discovering new options unnecessary or not worth their time.

The instructions and support by the supplier should have an effect on the milk yield and we see that farmers in the high milk yield group are overall very satisfied with the help. However one was one of the first farms with a robot, and was therefore helped a lot so these results actually cannot be taken into account. And the farmer with the highest milk yield per minute was not contempt at all with the support and help during implementation. So these results are contradicting. In the average milk yield farms were no complaints about support and instruction. And in the low milk yield farms there also where complaints. When this one farm in the high milk yield group is considered an outlier, it is possible to say that sufficient instructions and support by the supplier at least enables the farm to produce on average level.

Concluding, the main factors that can be changed to improve the performance of the system are the improvement of amount of data usage by farmer by giving more instructions and support about the management system and during the implementation of the system, this probably also benefit the perceived ease of use of the system from the farmers. Subsequently the farmer can pay attention to being more proactive in using the data, so be alert to certain changes which occur in the system and try to keep them monitored so action can be taken when needed. And monitor cows closely, so if something is off it can be spotted as soon as possible, if the farmer senses something is wrong he can check the cow individually in the system to see if T4C gives inconsistencies in cow
performance. Furthermore since the number of discussion partners effects the milk yield positively it could benefit the farmer to discuss farming practices, ideas or problems with more people. Finally, farms with pasture availability seem to be less efficient, even though the differences are very small, farmers could make sure pasture at least is not restricted to less than four hours per day optimize feed intake.

**Thesis evaluation**

A major limitation in this research is the limited sample size. The interviews and observations provided the researcher with in depth data, however this method was very time-consuming to conduct. Also because the farms to be visited where located in the east of the Netherlands and the researcher lives in the south of the Netherlands the data collection was very time consuming. When sample size is increased it is expected that differences can be identified more clearly and more effects on the milk yield per box time can be found.

Even though interviews provide very in depth information there are also weaknesses in this method. The flexibility of in-depth interviews might indicate that the results are not reliable, because it is hard to repeat the exact interview. However in this research the interviews were transcribed so the exact answers and questions are available. Secondly, the researcher was not an experienced interviewer, and therefore may have given unconscious signals to guide a respondent to an answer. There was however no possibility for the interviews to be conducted by somebody else. Therefore researcher practiced functioning of the observations and the interview by visiting two farms before data collection actually started. Thereby it is possible that the respondents give an answer which they think is socially desired. Which was noticed to happen in one interview where a farmer stated to use a lot of functions and options from the system, however during morning observations the researcher did not note the farmer to use the system at all. Furthermore it was hard to generalize answers and to make answers visible in the results, because it is hard to identify what is relevant and what not. Results cannot easily be quantified and therefore it is harder to draw conclusions.

The observations provided a well-drawn map of the journey of the farmer in their morning routine. And every time behavior was changed this was noted, so it is very reliable and the farmer cannot influence this because the researcher records the only behavior or task he is full-fulling. However there can be stated that because there was only one researcher observing this is too subjective. Nevertheless there was no possibility for a second researcher to join in this research.

Since the researcher was present on the farm, the validity of the study might have been affected. Because the farmers behavior could be affected or changed by the presence of
the researcher, in the phone calls and before the observations started the researcher however clearly stated that farmers should carry out their normal routine while they were being observed.

Additionally as stated earlier this research was conducted at farms in the east of the Netherlands and had a small sample size so it will not be applicable for all farms in the Netherlands. It however does give an indication about data used from the AMS and this will be interesting for future research about this subject additionally we choose to conduct the research within one company so it might also be applicable to other farms using this AMS.
7. Conclusions and recommendations

To answer the main research question first the sub-questions will be addressed. Firstly, the factors that influence the performance of the AMS found in literature are farmer characteristics (i.e. motivation in farming, interest in technology, proactive behavior, knowledge, use of data and management skills), the farm characteristics (i.e. pasture availability, cow traffic and farm size) and lastly the AMS characteristics (i.e. functions of the AMS, PU, PEOU and instructions and support by the supplier).

Secondly, what functions does the AMS used by the farmers in this study and how can they be used? The Lely Astronaut has five main functions; identification, milking, transport, feeding and cleaning. During each of these functions data is collected, which is all send to the T4C management system where the data is translated and made visible and usable for the farmer.

The main factors of farm, farmer and AMS characteristics (sub-question 3, 4 and 5) that have an influence on performance of AMS are displayed in figure 12.

![Diagram of factors influencing AMS performance](image)

Figure 12 Factors which are identified to influence the performance of the AMS

Additionally we address sub-question 6: What can be changed by farmer or producer to improve the performance of the system:

- The farmer can be more proactive in using the T4C management system and monitoring the cows.
- The farmer can find more discussion partners to discuss ideas and problems about farming with to increase motivation.
- The farmer should not restrict pasture to less than 4 hours per day.
- Lely can help the farmer understand and increase the data usage and perceived ease of use by optimizing instructions and support especially considering the T4C management system and help during the implementation of the robot.

To answer the main research question 'Which different management practices are currently used at AMS farms and how can these be changed to improve the efficiency of the AMS system?' Overall the farmer in all milk yield per box time (L/min) groups conduct the same tasks in their morning routine and all of them do not use all the available data. The main difference is that in farms with a low milk yield per minute routines are less structural, proactive behavior of the farmer seemed to be less and the farmer had less discussion partners in farms with low milk yield per minute. And these farmers where less contempt with the instructions and support they got. What is recommended to improve by farmer and producer is mentioned above.
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Appendixes

Appendix 1: Questionnaire farmers

Bedrijf

1. Sinds wanneer heeft u uw bedrijf?

2. Hoe groot is uw bedrijf?

3. Hebben uw koeien toegang tot grasland?

4. Heeft u een onbeperkt of beperkt begrazingssysteem?
   a) Onbeperkt
   b) Beperkt
      • Hoe lang hebben uw koeien toegang?
   c) Geen
      • Summerfeeding
      • Zomer stal voedering

5. Welk begrazingssysteem heeft u?
   a) Stripgrazen
   b) Rotatie standweiden
   c) Siesta grazen
   d) Continu grazen

6. Wanneer bent u overgestapt naar AMS?

7. Hoe is de opstelling van de stal?
   a) Vrij koeverkeer
   b) Gecontroleerd koe verkeer
   c) Gedwongen koe verkeer

8. Heeft u meerdere stallen?

9. Werkt u met productiegroepen?
10. Heeft u nevenactiviteiten die u uitvoert naast het runnen van de melkveehouderij?

11. Zijn er nog meer personen die u nodig hebt in u bedrijfsvoering en waar u regelmatig contact mee heeft?

12. Wat is voor uw bedrijf van toepassing:
   o Mijn bedrijf is heel modern en voor de toekomst ingericht
   o Mijn bedrijf is modern, maar ik moet wel steeds blijven investeren
   o Mijn bedrijf is indertijd efficiënt opgezet, maar behoeft wat aanpassingen
   o Mijn bedrijf is toe aan een reorganisatie
   o Mijn bedrijf is wat versleten, maar functioneert nog naar behoren
   Heeft u een toelichting op uw antwoord?

13. Wat karakteriseert uw bedrijfsvoering het beste?
   o Ik heb een basisboerderij zonder franje
   o Ik breng waar mogelijk verbeteringen aan in mijn boerderij
   o Ik standaardiseer waar mogelijk de bedrijfsprocessen
   o Ik manage de bedrijfsprocessen op basis van gegevens die ik krijg van de koelen, over de opbrengst en uit de registraties door de AMS
   o Ik optimaliseer de bedrijfsprocessen zodat ik de maximale opbrengst krijg

AMS en gebruik van de AMS in de praktijk

14. Heeft u alleen een AMS van Lely of nog meer apparaten?
   a) Lely Cosmix (Voeropname en Restvoer)
   b) Lely Vector (Ruwvoer per groep en Voerefficiëntie)
   c) Lely Grazeway
   d) Lely Calm (Melkopname en gewicht, kalveren)
   e) Lely Qwes (Activiteit & Herkauwen)
   f) Lely Discovery
   g) Anders namelijk, ...

15. Welke functies heeft uw AMS?
   a) Melkkleur (per kwartier)
   b) Vet-/eiwitgehalte in de melk
   c) Lactosegehalte in de melk
   d) Geleidbaarheid van de melk (per kwartier)
   e) Temperatuur van de melk
   f) Celgetalcategorie per koe per melking
   g) Gewicht van de koe
   h) Melkproductie
   i) Voeropname
   j) Restvoer
   k) Melktijd/dode melktijd
16. Vindt u het management systeem geleverd bij de A4 gebruiksvriendelijk?  
Ja/Redelijk/ Niet echt/ Nee

17. Vindt u het management systeem geleverd bij de A4 makkelijk te begrijpen?  
Ja/Redelijk/ Niet echt/ Nee

18. Heeft u veel tijd gespendeerd aan het ontdekken van de opties die de AMS heeft?  
Ja/Redelijk/ Nee

19. Welke rapporten gebruikt u allemaal tijdens de dagelijkse routine?  
   a) Gezondheid van de Koe  
   b) Melkproductie  
   c) Melkfilmmaliteit  
   d) Activiteit van de koe

20. Welke informatie gebruikt u tijdens uw dagelijkse routine?  
   a) Melkkleur (per kwartier)  
   b) Vet/-eewitgehalte in de melk  
   c) Lactosegehalte in de melk  
   d) Geleidbaarheid van de melk (per kwartier)  
   e) Temperatuur van de melk  
   f) Celgetalcategorie per koe per melking  
   g) Gewicht van de koe  
   h) Melkproductie  
   i) Voeropname  
   j) Restvoer  
   k) Melktijd/dode melktijd  
   l) (Max.) melksnelheid  
   m) Aantal melkingen  
   n) Aantal weigeringen

21. Wanneer gebruikt u de functies die u niet tijdens uw dagelijkse routine gebruikt?

22. De functies die u helemaal niet gebruikt vindt u deze onbelangrijk?  
   Ja/Nee

23. Als u alle functies een nummer mag geven waarbij 1 heel belangrijk is en 4 niet  
   belangrijk welk nummer geeft u dan?
Prestatie door de AMS

24. Is de A4 beter dan het vorige systeem wat u gebruikte?
   1) Ja veel beter 2) Beter 3) Neutraal 4) Iets beter 5) Niet beter

25. Is de financiële omzet gestegen sinds de implementatie van de A4?

26. Is de productie per koe/totale melkproductie gestegen sinds implementatie van de A4?

27. Is u tijd bespaard gebleven sinds implementatie van de A4? Zo ja, hoe denkt u dat dat komt?

28. Is de klauwgezondheid van de koeien veranderd sinds implementatie van AMS?
   Zo ja, heeft u daar getallen van?

29. Is de vruchtbaarheid van de koeien verbeterd sinds implementatie van AMS?

30. Zijn het aantal mastitis gevallen veranderd t.o.v. voor de implementatie van het AMS?
    Zo ja, hoe?

31. Moet u uw koeien vaak gaan halen om te melken?

32. Zijn er andere opvallende dingen veranderd sinds het gebruik van de AMS?

Ondersteuning bij het gebruik van de AMS door Lely

33. Toen u bent begonnen met gebruiken van de AMS, heb u veel hulp gekregen van Lely? Zo ja hoeveel en wanneer? Zo nee, waarmee had u hulp kunnen gebruiken?
    Ja/Redelijk/Niet echt/ Nee

34. Is het voor u eenvoudig om op dit moment hulp te vragen als u het nodig heeft?
    Waarom wel of waarom niet?
    Ja/ Nee

35. Hoe kan u op dit moment hulp vragen?
Boer

36. Wat is voor u van toepassing
   o Mijn kennis op gebied van technologie is helemaal bij de tijd
   o Mijn kennis op gebied van technologie is wat achterstallig
   o Ik heb echt bijscholing nodig op gebied van technologie
   o Ik heb nauwelijks kennis van technologie
   o Technische dingen laat ik aan een ander over
   Heeft u een toelichting op uw antwoord?

37. Wat is meer op u van toepassing:
   o U bent de eerste in uw omgeving die een nieuwe techniek uitprobeert
   o U bent wel geïnteresseerd in nieuwe technieken en toepassingen, maar wilt eerst zien hoe ze in de praktijk werken
   o U wilt eerst bewezen zien dat een nieuwe techniek ook echt werkt
   o U overweegt alleen een nieuwe techniek, als deze ook een duidelijk probleem oplost
   o U wacht met het aanschaffen van een nieuwe techniek, als de prijs fors is gezakt
   o Techniek is niet iets dat u boeit
   Heeft u een toelichting op uw antwoord?

38. Houdt u de technologische ontwikkelingen van de AMS zelf in de gaten?
   Ja/Soms/ Nee

39. Wat is voor u van toepassing:
   o U gaat naar de koeien kijken op het moment dat het programma een melding geeft
   o U kijkt met regelmaat naar het programma of alles nog in orde is
   o U let op het gedrag van de koeien en handelt daarnaar en houdt het programma in de gaten
   o U constateert veranderingen bij het programma en handelt preventief
   Heeft u een toelichting op uw antwoord?

40. Praat u veel over ideeën/ problemen die u ervaart op de boerderij met collega boeren? Zo ja met hoeveel mensen ongeveer
   a) Geen
   b) <5
   c) 5-10
   d) >10
Appendix 2.1 Customer Journey Example
## Appendix 2.2 Vervolg voorbeeld customer journey

### Time of the day

<table>
<thead>
<tr>
<th>08:00</th>
<th>08:05</th>
<th>08:10</th>
<th>08:12</th>
<th>08:22</th>
<th>08:30</th>
<th>08:39</th>
<th>08:45</th>
<th>08:50</th>
<th>09:00</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scheep voor boxen en spons + emmer voor waterbakken</strong></td>
<td><strong>Filter oud en nieuw</strong></td>
<td><strong>Waterslang, laser schoonmaak, borstel</strong></td>
<td><strong>Spons en water</strong></td>
<td><strong>Waterslang, laser schoonmaak, borstel</strong></td>
<td><strong>Trekker</strong></td>
<td><strong>Computer</strong></td>
<td><strong>Boxen krabber</strong></td>
<td><strong>Tractor</strong></td>
<td><strong>Computer</strong></td>
</tr>
<tr>
<td>wachtruimte, HP koeien weer toegang tot de robot</td>
<td>separatie koeien</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Waterbakken schoonmaken</strong></td>
<td><strong>Filter vervangen</strong></td>
<td><strong>Robot schoonmaken, ketting losmaken zodat HP koeien ook weer in de robot kunnen</strong></td>
<td><strong>MAUSE schoonmaken</strong></td>
<td><strong>Andere robot schoonmaken + ruimte schoon spuiten</strong></td>
<td><strong>Mest weghalen voor de robots</strong></td>
<td><strong>Uiergezondheid lijsten checken.</strong></td>
<td><strong>Boxen schoonmaken bij LP koeien</strong></td>
<td><strong>Voer aanschuiven en pinken mais voeren</strong></td>
<td><strong>Afspraak met werknemer van Lely</strong></td>
</tr>
</tbody>
</table>

**Used Technology**

- Lely astronaut
- Lely Astronaut
- Lely InHerd
- Lely astronaut
- Lely management systeem
- Producer Support
- Uitleggen over T4C, en vragen van de boer beantwoorden

**Producer Support**

- Uitleggen over T4C, en vragen van de boer beantwoorden
Appendix 3 Lely devices possible to connect to T4C

Figure: Possible technology to connect to T4C management software and data derived from these technologies (Lely, 2016)
Appendix 4 Figures from results

Figure 13 Data user profile of all farmers

Figure 14 Knowledge of on-farm technology and milk yield per minute per box time.
Figure 15 Number of AMS and milk yield per box time (L/min)

Figure 16 Age of the barn and milk yield per box time
Figure 17 Perceived usefulness and milk yield per box time (L/min)
Appendix 5 Example of Standard Operating Procedure (SOP) (Lely, 2014)