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## ROBOTIC MILKING AND THE DAIRY INDUSTRY

### **IMPLICATIONS OF THE INTRODUCTION OF AUTOMATIC MILKING ON DAIRY FARMS AN EXTENDED INTEGRATED EU PROJECT**

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#### Abstract

At the end of 2000, the European commission granted a research proposal on the implications of automatic milking. The project involves seven research institutes from six European countries and six manufacturers of automatic milking systems. The project is co-ordinated by the Research Institute for Animal Husbandry, Lelystad, The Netherlands. The project started December 1, 2000. Research will last until December 2003 and the overall project is expected to be finished in February 2004. To complete the project, in spring 2004 a symposium will be organized.

The project covers a four-fold objective namely, 1) to identify determinants for the adoption of automatic milking, 2) to assess the implications of the adoption, 3) to generate solutions for any adverse effects and to 4) disseminate results. These objectives are allotted over 11 different research fields, so called work packages. Within each work package specific tasks are executed related to the research questions involved. During the entire course of the project a total of 28 research reports will become available of which three were completed at the time of writing this paper.

A detailed description on the background of the project, the interaction between the partners and the work packages as well as the research questions per work package and the first results will be described.

#### Background

The idea of automating the complete milking process has been around for at least 25 years. Initially, the major challenge was to develop reliable, swift and practical techniques for locating teats and attaching teat cups. Various pioneering attempts showed the possibilities, but it was only in the late 1980's that machines with potential for commercial exploitation began to appear.

The past four years automatic milking systems are being installed at an increasing rate, mainly on dairy farms in North-west Europe. World-wide more than 1100 dairy farms are currently milking with an automatic milking system. More than 90% of this number is located in north-western Europe. Introduction of automatic milking systems on dairy farms involves far more

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than just replacing labour by equipment. It changes the whole method of farming. Nature and organization of labour will alter in the sense that manual labour is partly replaced by management and control, and presence at regular milking times is no longer required. Regular visual control on cow and udder health at milking times will, at least partly, be taken over by automatic control. Satisfactory facilities for cleaning of cows and teats, as well for separation of abnormal milk need to be incorporated into the automatic system. Milking equipment will be used for 24 hrs a day, which requires a high reliability of the system and adapted cleaning and cooling systems. Permanent admittance to the system will change cow activities, may require adjusted cow routing within the barn and will influence the possibilities of grazing. Moreover robotic milking may have an impact on the public acceptance of dairy farming and dairy products.

Up to now, research on automatic milking has mainly focussed on technical improvements of automatic milking systems to improve performance and capacity, and on development of cow routing systems which ensure the desired frequency of visits to the milking robot. However, many questions remained in the realms of the following themes:

1. Farm-level adoption determinants of automatic milking, and on-farm social-economic and environmental implications of adoption;
2. (Conditions for) societal acceptance of this new technology;
3. Impact on milk quality and possibilities to produce milk of indisputable quality;
4. Impacts on animal health and welfare, including combination of automatic milking with grazing;
5. Requirements for management information systems.

In 1999, the Research Institute for Animal Husbandry set up the preliminary ideas for an integrated EU project addressing these questions. Based on available expertise and knowledge within research institutes in various countries, the seven research partners currently within the project were approached for co-operation. Furthermore, all six manufacturers of automatic milking systems agreed to join the project.

### Objectives

The following objectives for the EU project were defined:

1. To identify determinants for the adoption of automatic milking on dairy farms in North-west European member states;
2. To assess the implications of the adoption of automatic milking systems, in the realms of farm-level social-economic aspects, public acceptance, milk quality, animal health, animal welfare and farm management support requirements;
3. To generate solutions for any adverse effects of a widespread use of automatic milking in an early stage of adoption;
4. To disseminate results among research centres, policy makers, farmers and farmers' services, manufacturers of milking equipment and dairy industry.

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### Work Packages & Partners Responsible

Upon the overall project objectives, 11 research issues were identified and elaborated in so called work packages (WP). Responsibilities and involvement of each of the partners with respect to the various WP's are presented in table 1.

Table 1 Partners involved in the EU project Automatic Milking

Name of participating organization	Contact persons	Responsible for/ involved in
Research Institute for Animal Husbandry The Netherlands	Dr Albert Meijering Yvonne v.d Vorst M.Sc. Kees de koning B.Sc.	- Co-ordination - Administration, WP4 - WP 7 and 11
Federal Dairy Research Centre Germany	Dr Karin Knappstein	- WP 5 and 6
Danish Institute for Agricultural Sciences Denmark	Dr Morten D. Rasmussen	- WP 3
Institute of Animal Health United Kingdom	Dr Eric Hillerton	- WP 8
Catholic University Leuven Belgium	Prof. Erik Mathijs Prof. Keith Roe	- WP 1 - WP 2
Swedish Agricultural University Sweden	Prof. Hans Wiktorsson	- WP 9 and 10
Swedish Institute for Agricultural Engineering Sweden	Dr Christel Benfalk	Involved in WP 7
Prolion Sales BV	Otto de Groot B.Sc.	Involved in all WP's
Westfalia Landtechnik GmbH	Dr. Beate Maassen- Francke	Involved in all WP's
Lely Industries NV	Aart van 't Land B.Sc.	Involved in all WP's
Insentec	Gerben Klungel B.Sc.	Involved in all WP's
Fullwood	Toon Kromwijk B.Sc.	Involved in all WP's
DeLaval	Fernand v. Hoven B.Sc.	Involved in all WP's

Below an overview of all 11 work packages together with the partner responsible (work package manager) is given.

#### *1. Socio-economic aspects*

Work package manager: Prof. Erik Mathijs – Catholic University Leuven, Belgium

The objectives of this work package are: (1) to identify and assess the farm-level determinants of the adoption of automatic milking by farmers. More specifically, its aim is to examine the

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importance of the characteristics and management style of the farmer and the organization and the environment of the farm on AM adoption. The second objective (2) is to assess the farm-level implications of the AM adoption, including the impact of the changing labour conditions on the farmers' quality of life, the impact on the economic, financial and environmental efficiency of the farm operation, and the impact on the organization of the farming business.

Recommendations will be set up regarding technical and actual policy measures concerning AM adoption.

### 2. *Public acceptance*

Work package manager: Prof. Keith Roe – Catholic University Leuven, Belgium

The objectives of this work package are: (1) to assess whether and under which conditions automatic milking is a production technology that will be accepted by society at large and (2) to identify the role of communication between industry and society in the process of acceptance.

Recommendations will be formulated both for relevant policy-makers and decision-makers in the dairy food industry.

### 3. *Redefinition of acceptable milk quality*

Work package manager: Dr. Morten Dam Rasmussen – Danish Institute for agricultural sciences, Denmark.

The objectives of this work package are: (1) to define acceptable milk quality of raw milk at time of milking and (2) to test the state-of-the-art of automatic milking systems for their ability to automatically detect and separate abnormal milk.

Recommendations will be made regarding the definition of acceptable milk quality of milk delivered by farms with an automatic milking system.

### 4. *Milk quality*

Work package manager: Yvonne van der Vorst M.Sc. – Research Institute for Animal Husbandry, The Netherlands

The objectives of this work package are: (1) to establish the effect of automatic milking on every parameter representing the quality of raw milk; (2) to identify, and subsequently quantify (epidemiological study), technical and management factors affecting milk quality obtained by automatic milking and (3) to gain in-depth information concerning the factors identified in objective 2.

Recommendations will be made to control the milk quality on farm level.

### 5. *Prevention of antibiotic residues*

Work package manager: Dr. Karin Knappstein – Federal Dairy Research Centre, Germany

The objectives of this work package are: (1) to determine the excretion characteristics of antibiotic residues in milk after treatment of healthy cows milked with different milking frequencies and intervals under experimental conditions and (2) to study the excretion of antibiotic residues in cows with naturally occurring clinical mastitis and milked in an automatic milking system.

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Results will lead to recommendations for management of antibiotic treatment of cows in automatic milking systems.

### *6. Effectiveness of automatic cleaning of udder and teats and effects of hygiene management*

Work package manager: Dr. Karin Knappstein – Federal Dairy Research Centre, Germany

The objectives of this work package are: (1) to develop methods for assessment of teat cleanliness before and after automatic cleaning procedures; (2) to evaluate the teat cleaning procedures of different AM-Systems and (3) to obtain applicable measures for prevention of teat, and subsequently, milk contamination on farms using automatic milking.

Recommendations will be made for on farm-management regarding teat cleanliness.

### *7. Optimal cleaning of equipment*

Work package manager: Erik Schuiling M.Sc. – Research Institute for Animal Husbandry, The Netherlands

The objectives of this work package are: (1) to determine the demands for the cleaning procedures by automatic milking systems; (2) to establish and optimise the effectiveness of the three different cleaning cycles of an automatic milking system in order to ensure a good milk quality under optimal use of time, energy, water and chemicals and (3) to determine the effectiveness of teat cup cleaning in order to prevent transport of mastitis pathogens from cow to cow.

Recommendations will be made on the most effective cleaning methods to be used for automatic milking systems.

### *8. Health and teat condition of dairy cows*

Work package manager: Dr. Eric Hillerton – Institute of Animal Health, United Kingdom

The objectives of this work package are: (1) to calculate the incidence of infectious and production diseases in herds using automatic milking, relating these to particular risks and management practices; (2) to show areas of risks in animal health created when cows are not milked using direct human help such that different management strategies are necessary; (3) to identify those areas of particular advantage to health from allowing cows choice of milking frequency and timing; (4) to identify changing risks and best management practices necessary when using automated milking to reduce the disease burden and safeguard milk quality and (5) to identify and specify the possible effects of automatic milking on teat condition and thus udder health.

Recommendations will be made on health and udder management on dairy farms with an AM system.

### *9. Welfare assessment of dairy cows*

Work package manager: Prof. Hans Wiktorsson – Swedish Agricultural University, Sweden

The objectives of this work package are: (1) to develop welfare indicators based on behaviour and health for implementation in a welfare assessment system for automatic milking systems; (2) to establish relations between ethological, physiological, metabolic and health parameters, which

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further strengthen the interpretation of welfare parameters and (3) to describe a full welfare assessment system relevant for decision support in an AM dairy herd.

Recommendations for an optimal herd welfare on farms with an automatic milking system will be presented.

### *10. Grazing*

Work package manager: Prof. Hans Wiktorsson – Swedish Agricultural University, Sweden

The objectives of this work package are: (1) to document the frequencies and distributions of visits to the automatic milking system in dairy herds under grazing conditions (2) to study and conclude if it is possible to exploit the cows natural eating and resting behaviour in a system combining automatic milking and grazing without stressing the cows and decreasing the milking efficiency and (3) to develop and test grazing strategies to be used on farms with an automatic milking system. Possibilities of different grazing strategies will be outlined.

### *11. Demands and opportunities for operational management support*

Work package manager: Wijbrand Ouweltjes M.Sc. – Research Institute for Animal Husbandry – The Netherlands

The objectives of this work package are: (1) to generate a list of demands for operational management with an automatic milking system relative to conventional milking; (2) to compare the possibilities of available automatic systems with the list of demands; (3) to signal shortcomings and list possibilities to overcome these.

This work package aims to give a description on how to use information to manage specific processes in dairy management on a farm with an automatic milking system. If there are shortcomings, possibilities to overcome these are suggested.

### Results

The outcomes of the EU project will be disseminated as much as possible. This will take place in the form of research reports, articles, the project web-site and personal communication on symposia and congresses. Below, each aspect will be highlighted. This paragraph will be concluded with a presentation of the first results coming out of the project.

### *Deliverables*

The reports coming out of the project are called ‘deliverables’. Depending on the work performed within a work package one to four deliverables are produced per work package. All deliverables will be placed on the project web-site. Table 2 provides the list of deliverables to be completed during the course of the project.

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Table 2 List of deliverables

No.	Work package	Deliverable title	Delivery date
1	1	Report providing a literature review on the determinants and implications of technology adoption	June 2001
2	1	Report providing a qualitative and quantitative analysis of the determinants of adoption of automatic milking	December 2002
3	1	Report on the qualitative and quantitative implications of automatic milking	September 2003
4	2	Report providing a literature review on societal acceptance of technology	June 2001
5	2	Report on societal acceptance of automatic milking	September 2003
6	3	Report describing consequences of definitions of acceptable milk quality for the practical use of automatic milking systems	November 2002
7	3	Report on the possibilities of automatic milking systems to separate milk based on quality	May 2003
8	4	Report with the effects of automatic milking on the quality of produced milk	November 2001
9	4	Report with farm and management factors affecting milk quality and motivation for further research	November 2002
10	4	Report with results of detail studies on causes of decreased milk quality	November 2003
11	5	Report on influences of milking intervals and frequencies in automatic milking systems on excretion characteristics of different antibiotics in milk	July 2003
12	5	Recommendations for management on antibiotic treatment of cows in automatic milking systems	September 2003
13	6	Protocol for evaluation of teat cleaning systems	May 2002
14	6	Report on the effectiveness of cleaning procedures in different automatic milking systems	May 2003
15	6	Report on hygiene measures resulting in adequate teat cleaning	September 2003
16	7	Report describing the various methods used to clean equipment of an automatic milking system	July 2001
17	7	Final report describing methods to optimize the different cleaning systems	July 2003
18	7	Report on effectiveness of optimized teat cup cleaning with respect to prevention of transfer of mastitis pathogens from cow to cow	November 2003

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19	8	Report containing an interim summary of disease incidence on farms converting to automatic milking	November 2002
20	8	Final report on changes in disease incidence on farms over the last period of conventional milking and the first year of automated milking	November 2003
21	8	Report containing best knowledge from the literature on effects of milking conditions on the teat end	July 2002
22	8	Report on the avoidance of problems of impaired teat condition when using an automated milking system	May 2003
23	9	Report describing a protocol for assessing animal welfare in an automatic milking system	November 2001
24	9	Report describing the relation between behaviour, physiological, metabolic and health parameters of cows held on a farm with a milking robot	November 2002
25	10	Report containing results of a survey on applied grazing strategies	March 2002
26	10	Report on stimuli for motivations of cows to visit the milking robot	November 2002
27	10	Report with grazing strategies and their effect on animal welfare and system performance	November 2003
28	11	Report with demands for management information systems and overview of the possibilities of current systems	November 2003

### *Web-site*

In May 2000 the web-site of the project became official. Its address is <http://www.automaticmilking.nl>. The site consists of general project information, latest news, a description of the work packages, partners involved, and deliverables planned. More importantly, all articles and deliverables coming out of the project are placed on the site. These can all be downloaded. Up to now, three deliverables are accessible. Two more will be placed on the site in February 2002.

### *First results*

Thus far, three deliverables have been completed. Their titles, authors and abstracts are given below.

#### *Deliverable no. 1 Implications of the introduction of automatic milking on dairy farms*

*Meskens, L., M. VanderMersch and E. Mathijs*

*Literature review on the determinants and implications of technology adoption.*

Recently, the general literature not only studies the impact of farm size, human capital, financial and institutional constraints on technology adoption, but it more and more tries to take into consideration the role of uncertainty and timing. Many farmers delay adoption to wait for more information (less uncertainty) concerning the technology itself as well as the institutional environment.

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The literature on the socio-economic determinants and implications of AM-system adoption is found to be limited to simulations and case studies. Hence, it is impossible to generalize their results. Moreover, in addition to a trade-off between the direct financial costs and benefits of AM-system adoption, the AM-system also brings about non-financial costs and benefits which are difficult to measure, such as increased flexibility of the farmer's working day, impact on animal welfare, etc., but which are important elements in a farmer's choice.

*Deliverable no. 4 Public acceptance of automatic milking*

*Roe, K. and H. van den Bulck*

*Literature review on acceptability of and public opinion on automatic milking systems.*

The overall success and longevity of the milk robot as a technological innovation will not only be determined by the fact that it is economically profitable, technologically sound and user-friendly but also by the possibilities of gaining a positive image and of being accepted by the general public – consumers. An initial analysis led to the identification of some key perspectives on the topic.

First, the interpretation and acceptance of the use of milk robots in dairy farming must be understood within the context of contemporary society. Second, a closer look is taken at the processes and agents through which public opinion is formed within this societal context. Finally, the importance of a pro-active approach towards information and communication regarding the new technology is evaluated. Being sensitive to these issues and dealing pro-actively with them, can help to establish a positive view with regard to the milk robot and contribute to its widespread public acceptance.

*Deliverable no. 16 Optimal cleaning of equipment for automatic milking*

*Schuiling, E. and J. Verstappen-Boerekamp*

*Investigation of systems, procedures and demands.*

An overview is given of the cleaning systems and strategies of eight different automatic milking systems, based on information given by the manufacturers through interviews.

Three different cleaning procedures are distinguished: system cleaning, unit flush and cluster flush.

System cleaning is divided into three phases, a lukewarm pre-rinse, major cleaning and the post-rinse. An important difference between cleaning procedures for the major cleaning is boiling water cleaning in a direct-to-drain system and a circulation cleaning at lower temperatures. Most of the systems use a circulation wash.

The unit flush is a part of all systems. Next to its basic function of removing residues of abnormal milk, it is used to prevent drying of the milk inside the system after some idle time. Two out of eight systems are able to flush the unit after a certain number of milkings. The effect of flushing the unit on milk quality is so far unknown.

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The cluster flush is performed after every milking for all AM-systems. Though the amount of water per flush is low, it takes a lot of water in total because of the high number of milkings per unit. The effect on udder health of a rinse with a small amount of water should be established by research, including rinsing with added disinfectants.

Many differences are seen when the different systems are compared. Follow up studies within WP7 will be performed to find the most optimal condition for milk equipment cleaning.

### Current Status

At the moment that this paper was written, ten out of eleven work packages had started and three deliverables were completed and two were under construction. Some delay due to the outbreak of Foot and Mouth disease in the Netherlands and Great Britain occurred. However, it is still believed that all deliverables can be achieved before the end of the project. Co-operation between partners and within work packages is continuing well. Expectations for future results are high and much dissemination will follow.

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### References

Meskens, L., M. VanderMersch and E. Mathijs (2001) Literature review on the determinants and implications of technology adoption. Deliverable no. 1 of EU project 'Implications of the introduction of automatic milking on dairy farms', work package number 1, Socio-economic aspects of automatic milking.

Roe, K. and H. van den Bulck (2001) Literature review on acceptability of and public opinion on automatic milking systems. Deliverable no. 4 of EU project 'Implications of the introduction of automatic milking on dairy farms', work package number 2, Public Acceptance of Automatic Milking.

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Schuiling, E. and J. Verstappen-Boerekamp (2001) Investigation of systems, procedures and demands. Deliverable no. 4 of EU project 'Implications of the introduction of automatic milking on dairy farms', work package number 4, Optimal cleaning of equipment for automatic milking

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