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Analysis of Three Different Sow Identification Systems

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ANALYSIS OF THREE DIFFERENT SOW

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ABSTRACT

Circle Four Farms (C4F) is the largest sow-breeding farm in the state of Utah and is currently increasing its breeding barn capacity to boost production. This growth has also been accompanied by adoption of the latest technologies for collecting and keeping sow records. C4F recognizes that timely, updated, and accurate records are of great importance to successful management. This study was performed to weigh the costs and benefits associated with the following three separate identification and tracking systems for swine that are employed at C4F: (1) the Manual System (MS)—under this system, sow identification and data are collected and entered manually into the main computer system located in the office of the breeding unit; (2) the Hand-Held Computer (HHC) System, or semiautomated system. A portable computer (HHC) is used to enter sow identification and data on site. The information is then downloaded into the personal computer in the office. This system reduces the need for paperwork; (3) the Electronic Identification (EID) System, or fully automated system. Each sow is tagged with an electronic transponder tag (ETT) used to identify the sows. The breeding unit employing this system uses a wand (scanner) attached to the HHC to identify sows electronically by scanning the ETTs. The information is then downloaded to the main computer in the office.

Two strategies were used to evaluate the effectiveness of the three systems: (1) a time motion study in which the relative time savings associated with each system were studied (five major events

in the sow's productive life were timed, including arrival, breeding, farrowing, weaning, and culls) and (2) error identification and estimation.

The results obtained from the breeding unit operating on the MS indicated a significant loss of time in collecting and entering the data compared to the other two systems. We also found significantly more errors in the MS compared to the two more automated systems. The MS was discontinued by C4F before the completion of the study due to the obvious inefficiency of the system in comparison with the other two systems.

The automated systems (HHC and EID) were compared to each other. The main cost difference between the HHC and the EID systems is the cost associated with the ETTs. The tags cost $4 per tag, or a total of $20,000 for a 5,000-sow unit. The transponder tags are reusable and have been recommended to be used four times. If sows remain in the breeding herd with a target productive life of 7 parities (2.5 years), then each ETT will have a useful life of 10 years. However, C4F estimates that technology will be updated or replaced between 3 and 5 years. Such equipment would include the hand-held computers and the ETTs.

In the time motion analysis, the EID system saves 13 hours per year in a 5,000-sow unit when compared to the HHC system. With a labor cost of $14/hr., this indicates a savings of $182 per year, or a net present value of $1,220 for 10 years in a 5,000-sow unit using the EID. If the ETTs were depreciated over 5 years, as is the case at C4F, the net savings from the time motion study would be $727 for five years for a 5,000-sow unit. This net time savings obviously does not outweigh the cost incurred in the ETTs.

Herd audits were used to find sow identification errors over a 10-month period. The manual system incurred a significantly greater number of errors (208 errors) than the more automated

systems. The HHC system incurred 10 errors while the EID system had only two errors in the 10-month period, or 9.6 fewer errors per year compared to the HHC system. The method used in this study to determine the value of preventing errors was to calculate the average cost of preventing errors from occurring, if the units employed the EID instead of the HHC system. The cost incurred using ETTs rather than the hand-held computers was calculated at $2,799 per year for 10 years.[1] This implies a cost of $291 per error if the tags were used over 10 years, or $490 per error if they are used only 5 years. Unless the farm manager is willing to pay this amount to avoid the occurrence of errors, the cost of the ETTs will outweigh the benefits. This cost should be compared to the benefits and gains associated with preventing errors. Benefits reduce if not eliminate the number of audits performed, thus, minimizing unproductive feed costs and using farm space to its fullest capacity. Further studies could be conducted to find the value of these benefits and compare them to the costs.

Although the EID system saves time in collecting and entering data and has fewer errors than the HHC system, the benefits of the time savings alone do not outweigh the cost of the ETTs, unless relatively high costs are incurred in correcting errors. The HHC system, as compared to the MS system, has proven to save a significant amount of time and greatly reduce the errors. The HHC also minimizes costs when compared to the EID system.

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[1]The savings found in the time motion study was subtracted from the total cost of the ETTs ($20,000-$1,220 = $18,780) and an interest rate of 8% was used over a 10-year period.

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ANALYSIS OF THREE DIFFERENT SOW
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INTRODUCTION

In 1994, Circle Four Farms (C4F) was established in Millard County, Utah. As a result, hog production of Utah tripled by 1995. As this industry continues to grow and increase its production capacity, timely, updated, and accurate records are of even greater importance to successful management. Good records are important to producers interested in obtaining maximum production efficiency, and the heart of good records in raising swine is sow identification. Identification is essential to a good selection and management control program based on animal productivity. In general, recordkeeping requires relatively little time, yet it enables producers to answer many questions about production efficiency. Advanced technology contributes to many phases of modern swine production, including recordkeeping, and producers are investigating new technological methods in swine identification.

C4F has built large breeding units with capacities of up to 5,000 sows per unit. Management and staff of the breeding units realize the importance of detailed and accurate production data. They have tried different methods of swine identification and recordkeeping that save time and maintain accurate, quality data. As the breeding units have increased in size, C4F has implemented two advanced, electronic methods of swine identification: hand-held computers (HHC) and electronic identification (EID) systems. These solutions were installed in addition to the manual system (MS) already employed at the units.

The objective of this study is to weigh the costs and benefits associated with these three separate identification and tracking systems for sows. The systems are evaluated by two different strategies: (1) the time savings associated with the three systems or the time-motion study, and (2) a reduction in errors associated with the systems.

The MS

Breeding and farrowing information were recorded each day on site onto lists or personal Pigtale[3] cards along with the sows identification number. This information was then entered into a central personal computer at the end of each working day.[4] Because the information was copied twice, it was anticipated that this system would take more time than the others in the data collection process. The probability of finding errors was also expected to be greater than in the two automated systems. The MS is set as the benchmark of comparison with the other two systems.

The Semiautomated System (HHC)

The HHC system was implemented to reduce paperwork, decrease the time spent on off-production activities, and increase the accuracy and efficiency of the information needed. A sow's identification number (from the regular ear tag) was entered manually into a HHC on site and was followed by the information on the events that had transpired. At the end of each working day, the data in the HHC were downloaded to a central personal computer. This system was expected to save time and decrease the number of errors in comparison with the MS.

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[3]Pigtale cards are the 3x5 cards each technician in the unit carries upon which they record events that occur as they perform their daily duties. They are used mainly in the farrowing houses to record piglet losses. At the end of the day, the cards are gathered and the information is entered into the central system.

[4]All the sow breeding units at C4F, regardless of the sow identification system used, is equipped with a personal computer used for information and data organization.

Fully Automated System (EID)

The EID system includes a Hand-Held computer with a transponder reader or wand that records the sow's identification electronically from a transponder located in a special ear tag, the electronic transponder tag (ETT). Technicians scan the ETTs instead of manually punching the sow's identification into the HHC. Therefore, it was anticipated that this system would be the most reliable for providing data with greater accuracy and saving the most time in collecting the information.

OVERVIEW OF METHODOLOGY

The three swine identification systems were evaluated using the following two srategies: (1) time efficiency—a time-motion study that estimated the time savings associated with each system, and (2) error estimation—an evaluation of the cost associated with a reduction in sow identification errors.

Time Efficiency

A time-motion analysis was done of different procedures under the three systems. This was done by:

1. Studying the different events of the breeding units, and carefully defining the timing process for the events included. The definitions of the events and tasks within the events are carefully defined in Appendix A.

2. Completing a random sample of the time and effort required to complete the events defined under the three systems.

3.   Performing a statistical analysis to determine any statistically significant increases in time savings under the automated systems in comparison with the MS.

The events that were chosen for this portion of the study were based on the following factors: (1) events common to all units under the three systems, (2) events that occur regularly in the breeding units, and (3) systems studied that play a major part in collecting and recording the information on the events. The events were divided up into two groups depending on the timeframe in which observations were gathered. The following is a list of the events that were timed and the systems under which observations were collected:

1.   Events observed and timed during the summer of 1996:

      Arrival: (MS, HHC, EID)
      Breeding: (MS, HHC, EID)
      Culling: (MS, HHC).

2.   Events observed and timed during the spring of 1997:

      Farrowing: (HHC, EID)
      Weaning: (HHC, EID)
      Breeding: (HHC, EID)
      Culling: (EID)

This grouping was necessary in order to collect samples needed for the defined events occurring both in the breeding barns and the farrowing houses. When the study began in the summer of 1996, the EID system had just been implemented in a 5,000-sow unit. The farrowing houses of the unit using the EID system were not yet functional and would not be for at least four months. Therefore, it was necessary to return and complete the study during the spring of 1997. Breeding observations were retimed during this time in order to compare with them with the observations

collected during the previous summer. The comparison would show any change in the technicians' efficiency in using the systems.

Three of the C4F breeding units were selected for the study in 1996, with one unit using the MS, one using the HHC system, and one using the EID system. In the summer of 1996, the MS was well-established in one of the 5,000-sow units, but the EID and HHC systems were new to the 5,000-sow units where the study was being performed. Although the technicians were trained in using the portable computers, they still faced some problems due to lack of experience in using these systems. Upon returning in the spring of 1997 to complete the study, some changes had been made, i.e., the MS was completely replaced by the HHC system due to the results of the data collected and analyzed during the summer. A data technician was assigned to each unit and was responsible for the data collection. The data technicians were well-trained in using the portable computers (the HHC and EID systems), and became well-experienced by the time the spring observations were gathered.

During the summer of 1996, cullings were timed at the units using the MS and HHC systems. The EID system recorded the culls no different from the HHC system, not yet realizing the system's full potential. By the end of the summer, the technicians using the EID system were informed on the best and quickest method of inputting culling data. Therefore, observations of culls in the unit using the EID system were collected during the spring to time the true use of the EID system.

Error Estimation

The average cost of reducing errors by using the EID system verses the HHC system was estimated by two methods. First, herd audits were completed in the units operating the three systems and identification was made of the number of sow identification errors. The herd audits were

performed after the units had been operating under the systems for 10 months. Second, the cost was calculated that is associated with preventing errors due to the use of one system in comparison to using the others.

FINDINGS AND STATISTICAL ANALYSIS

Summary of the Time Motion Study

A time-motion analysis of the three systems was performed for five events occurring regularly in the units. The five events timed were: arrival, breeding, farrowing, weaning, and culling. Each event and tasks included in the events are carefully defined in Appendix A. Observations were collected at random from the three units employing the three systems. All observations were recorded in seconds and adjusted for the number of technicians involved in each task. The results of the statistical analysis using SAS are found in Appendix B.

Arrivals

All new gilts arriving into the herd receive an ID number. These new ID numbers are entered into the sow tracking systems. The following are the sample averages obtained under the three systems:[5]

System	Tasks	Avg. Time/Task	Total Avg. Time/Event
MS	Tagging	17.9 sec.	19.0 sec.
	Data entry	1.02	
HHC	Tagging	15.58	21.1
	Data entry	5.51	
EID	Tagging	9.58	34.53
	Data entry	24.95	

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[5] A full report of the statistical findings including the standard deviations can be found in Appendix B.

There was no statistical difference between the MS and the HHC system, but these two systems were found to be statistically different from the EID system. Tagging took less time under the EID system than under the other systems. This is due to the tagging technique used in the unit. Because the ETTs are valuable and reusable, they are placed away from the ear's rim and closer to the harder more supportive parts of the external ear. This prevents the tag from easily tearing out of the sow's ear. In the units using the EID system, the tagging is performed while gilts are snared, thus controlling the gilts and simplifying the tagging task itself (refer to the definition of arrivals in Appendix A). Data entry for the MS requires significantly less time than other systems. This is because new gilt information is entered into the desktop computer in batches of 100 gilts at a time. The data entry for the EID system accounts for the large difference in the total average time spent in this event. With the EID system, the new gilts' identification information are entered individually and separately into the system because the regular ear tag numbers have to be associated with the corresponding transponder codes for each gilt.

Breeding

All sow breeding information is recorded into the computer system to keep track of the productivity of each sow. Two sets of observations were collected for this event under each system: summer 1996 observations and spring 1997 observations. The second set of observations was performed to measure changes in the technicians' efficiency in using the systems. An increase in efficiency was expected due to changes that occurred in the methods of collecting data under the HHC and EID systems and the technicians' increase in experience using the systems. The following

are the average times in seconds needed for collecting the breeding information during the summer and spring.[6]

System	Tasks	Avg. Time/Event Summer 1996	Avg. Time/Event Spring 1997	Difference (Summer - Spring)
MS	Creating list (22.98 sec.) Entering data (23.67)	46.73 sec.	NA	NA
HHC	Entering data	31.1 sec.	21.25 sec.	9.86
EID	Entering data	37.89 sec.	16.73 sec.	21.17
	Difference (HHC - EID)	-6.79 sec.	4.52 sec.	

About one-half the total time required to collect data under the MS is used in creating the list. There is an obvious statistical difference seen between the MS and the automated systems in the data collected during the summer. These findings were part of the reason C4F discontinued the MS after the summer of 1996. Subsequently, no data were collected during the spring. From the summer data we also notice a significant 6.79 second difference between the automated systems in favor of the HHC system. While the spring breeding data show a significant difference of 4.52 seconds, this time is in favor of the EID system.

It is clear that there has been an increase in time efficiency with both of the two automated systems (HHC and EID) systems. For example, the HHC system had an increase in time savings of 9.86 seconds, while for the EID system, the time savings increased by 21.17 seconds. This significant amount of time savings within the systems is a result of overcoming the steep slope of the learning curve. The data technicians who have been assigned to each unit are well-trained and capable of handling the systems with minimal problems. The large time difference in the unit using the EID system is due to the change in the method of collecting breeding information. During the

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[6]A full report of the statistical findings, including the standard deviations, can be found in Appendix B.

summer, technicians would walk behind the crates, hop into each crate, and reach for the ear tags to scan them. This took time and effort. This method was followed because the sow breeding cards, which contained the breeding information, were hung at the back of the crates. When returning in the spring, the sow cards were hung in a manner that allowed the data technician to walk along the front of the crates, see the information on the sow cards. and scan the ear tags with obvious less time and effort.

Farrowing

The farrowing information, born live, stillborn, and mummies, are entered daily into the data systems. Farrowing data were collected during the spring of 1997, at which time only two of the three systems were operating—the HHC and the EID. The following are the average times needed for the entry of the farrowing information under the two systems.[7]

System	Total Avg. Time/Event
HHC	17.59 sec.
EID	14.3 sec.

At a 95% confidence interval, the EID system had a significant 3.28 second gain in comparison to the HHC system.

Weaning

Piglets are weaned when they reach the average age of three weeks. They are then transferred to nurseries and the sows are returned to the breeding barns. The number of piglets weaned and the condition of the sow at weaning time are entered into the data systems. Weaning data, as was the

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[7]A full report of the statistical findings, including the standard deviations, can be found in Appendix B.

case with farrowing data, were collected in the spring of 1997 and only for the HHC and the EID systems.[8]

System	Total Avg. Time/Event
HHC	10.3 sec.
EID	10.5 sec.

The average time for the data technician to enter the weaning information in the two units were found to be very close. At a 95% confidence interval, there was no significant difference between the two systems in this event.

Culling

Once a sow becomes less productive, she is shipped out of the unit and culled. Collecting the culling information was different under each system studied (definitions are available in Appendix A). The MS starts this event by collecting the data onto a list or form at the site and then copying the information into the desktop computer. The HHC system involved entering the culling information into the system on-site. As for the EID system, because the ETTs are reusable, the time involved in the culling event includes the time used in the removal of the ETTs in addition to entering the culling information into the system. The following are the average times in seconds needed for the culling event.

System	Tasks	Avg. Time/Task	Total Avg. Time/Event
MS	Making list	7.24 sec.	12.47 sec.
	Data entry	5.23	
HHC	Data entry	6.81	6.81
EID	Data entry	10.87	29.99
	Tag removal	19.12	

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[8]A full report of the statistical findings, including the standard deviations, can be found in Appendix B.

It is very clear that the EID system requires more time than the other two systems. The reason for this is the extra time required for the removal of the tags, which is not a concern for the other two systems. There is a statistically significant difference between each of the systems. The HHC system has a gain of 23.18 seconds compared to the EID system.

Analysis of Combined Events

To combine the results for the events timed, it is important to take into consideration the number of times the different events occur in the life of a sow. Two assumptions were made: (1) there is an average of 7 parities during the productive lifetime of a sow (which averages about 2.5 years), and (2) an average of 15% of bred sows are rebred. The breeding data collected during the spring were used when combining events. The following events are combined: arrivals, breeding, farrowing, weaning, and culls.[9]

System	MS	HHC	EID
Events:			
Arrivals	19.0 sec.	21.04 sec.	34.53 sec.
Breeding	397.2	180.6	142.2
(7 parities, 15% rebreeds)			
Farrowing	NA	123.13	100.1
(7 parities)			
Weaning	NA	72.1	73.5
(7 parities)			
Culls	12.47	6.81	29.99
Total		403.69	380.32

The HHC system requires a total of 403.69 seconds over the lifetime of the sow, while the EID system requires 380.32 seconds. The EID system gains an advantage over the HHC system in the farrowing and breeding events. On the other hand, culls and arrivals are the two events that

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[9]A full report of the statistical findings, including the standard deviations, can be found in Appendix B.

cause a significant amount of time loss for the EID system. These two events deal with the actual handling of the ETTs, either in their application or removal.

Financial Calculations and the Feasibility
of the EID System Based on the Time-Motion
Study Only

The initial investment for the EID, not including the cost of the wands, is $4 per ETT ($20,000 per 5,000 sow unit) and each transponder tag can be used for an average of ten years.[10] The time savings of the EID system, as compared to the HHC system over the combined events, is 23.37 seconds over 2.5 years per sow, or 12.98 hours of savings per year for a 5,000-sow unit. With an average labor cost of $14 per hour, there is a savings of $181.72 per year in a 5,000-sow unit using the EID system. Over a 10-year period and at an 8% annual interest rate, the EID system saves a net present value of $1,220.

Based on the results of the time motion-study and given the information above, the ETTs are worth $0.24 each. To break even with the $4 initial investment, there should be a time savings of 137.22 seconds per sow (190.58 hours/5,000 sows) in a year compared to the HHC system.

FINDINGS AND ANALYSIS OF THE HERD AUDITS

Summary of Herd Audits

C4F has set a 2% acceptable error level for its breeding units. Herd audits are performed on an as-needed basis only, which is usually only once a year in the units that employed the MS. For this study, a complete herd audit was performed in the three units used in the study. A 10-month

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[10]Transponder tags are reused on four sows. If sows live the target productive life of seven parities or an average of 2.5 years, then the transponder tags should last about ten years.

period from time of start-up to the audit was allowed for all three units (systems). The audits determined the number of errors that occurred due to data collection. Three types of errors were recorded: (1) animals on the computer that were not in the herd, (2) animals actually in the herd that were not on the computer, and (3) animals entered into the wrong breeding group. The results of the audits were as follows:

The Manual System

140   Animals on the computer that were, in reality, not in the herd.
10   Animals actually in the herd that were not listed on the computer record.
58   Animals entered into the wrong breeding group.

At the time of the audit in the unit employing the MS, inventory was 4,886. Consequently, the number of errors constitutes a 3.06% level of discrepancy, which is greater than the 2% acceptable level of errors C4F has established.

The Hand-Held Computer System

6   Animals on the computer that were, in reality, not in the herd.
0   Animals actually in the herd that were not listed on the computer record.
4   Animals entered into the wrong breeding group.

At the time of the audit, inventory was 4,623, constituting a discrepancy of 0.13%.

The Electronic Transponder System

2   Animals on the computer that were, in reality, not in the herd.
0   Animals actually in the herd that were not listed on the computer record.
0   Animals entered into the wrong breeding group.

At the time of the audit, inventory was 4,919, constituting a discrepancy of 0.04%.

Analysis of Audit Findings

It is clear that the MS incurred more errors than the automated systems, while the EID system is clearly the most efficient system, as defined by fewest errors. There is a cost associated with each sow identification error, which could be calculated by econometric analysis, that would include factors such as the costs associated with finding errors (herd audits), the cost of correcting the errors, the opportunity costs associated with the feed that is used unproductively, or farm space that is not used to its full capacity, as well as other direct and indirect costs that make this a more complicated issue and is subject for further studies. However, the approach taken in this study is to calculate the average cost a firm using the EID system is implicitly willing to pay to prevent errors from occurring. This analysis focuses on the comparison between the HHC and the EID systems.

From the audit findings, the EID system had only two errors during the 10-month period in which the audit was performed, while the HHC system incurred ten errors in 10 months. In other words, with the EID system there were eight fewer errors in 10 months (9.6 fewer errors per year) in comparison to the HHC system. Calculating the cost associated with eliminating errors by using the EID system, it costs $3.76 per ETT ($4.00 - $0.24 saved due to the time efficiency) or $18,780 for a 5,000-sow unit. With an 8% annual interest rate (discounting over 10 years), an estimated $291 is the cost paid to prevent an identification error from occurring when using the EID system instead of the HHC system. If C4F depreciates the EID system over five years, then the cost of preventing an error would calculate to be $490. This cost should be compared to the benefits of preventing errors discussed above, including a reduction in the number of audits performed, minimizing feed costs, and using the farm space to its full capacity.

REMARKS AND RECOMMENDATIONS

Technician's Performance and Speed

By nature, some people are quicker at performing tasks than others. This, of course, is reflected in the timing for the observations taken at each unit. During the summer 1996 a variety of technicians were timed while performing the tasks at hand. This was done to minimize the possibility of biased results. But during the spring, one technician did all the data entry, therefore it was not possible to collect a variety of performance samples from different technicians.

Additional Expenses Associated With the
EID System

The ETTs are reusable and can be used with at least four sows. The tags need to be washed and disinfected before reusing them. This additional time and effort needed would decrease the time savings for the EID system.

Equipment Durability

The wands have been known to break easily. There is a weak connection between the wand handle and the probe, which is where most wands break. Although the ETTs last for an average of 10 years, with an initial investment of $20,000 per unit in tags alone, it seems that the wands will be a continuous expense unless they are manufactured to last longer.

Handling the ETTs

It is clear from the time-motion study findings that the EID system loses a significant amount of time savings during the tag application and removal. If the ETTs were made to be applied and

removed with greater ease and time savings, then greater gains would be realized and the ETTs would be of greater value.

Cost Associated With the Regular Ear Tags

The cost of the regular ear tags, which are used in all units, is $0.09 per tag. This expense could be avoided in the unit using the EID system. There could be a savings of $450 for 5,000 sows if the regular ear tags were discontinued in that unit.

CONCLUSION

As sow breeding operations become larger, the need for timely, accurate data is of great importance to producers who are concerned with increasing their production capacity. In this study two strategies were used to study three swine identification and tracking systems: the time-motion study and error estimation. The three systems studied were the MS, HHC, and EID.

It is clear from the findings of both approaches that the MS requires a significantly greater amount of time and incurs the most errors. It is also concluded that the time savings gained by using the EID system is only a fraction of its cost. Therefore, the time benefits are not significant enough to recommend the EID system, based on the time-motion study alone. However, if C4F is willing to pay an average of $291 to prevent each error, then the EID system would be considered cost-effective.

The HHC system has proven itself to be more efficient than the MS. There is an obvious reduction in time required in collecting and entering sow information. There is also a significant reduction in errors. The HHC system also has a cost advantage over the EID system. The HHC

system does not incur the additional significant cost associated with the ETTs and wands. Although

the EID system saves time in collecting and entering data and has fewer errors than the HHC system,

these benefits do not outweigh the costs incurred without paying high costs for preventing errors.

APPENDICES

Appendix A: Methodology of Timing

Defining the Events and Tasks for the
Time-Motion Study

The events that were included in the time-motion study were carefully defined before collecting the observations so as to compare similar processes between systems. The definitions restricted the timing process to the action of data collection and information recording under the systems. Therefore, avoiding activities that do not relate to data collecting and entering or that are considered common steps under the three systems should not differ from one system to another.

Each event is made up of tasks, and each task is a part of the data collecting process. The number of tasks may differ from one recording system to another within the same event. In the definition, two points in time are specified, these are the starting and stopping points of the stop watch (SW). The SW will start at the beginning point of the recording process and stop when the process is over.

The following are detailed definitions of the events and tasks within the events under each of the three systems studied. All the observations were recorded in seconds and adjusted for the number of workers involved in the event, thus comparing man-hours.

Arrivals

New arrivals are treated differently at each unit, but as a general rule the new gilts are identified (tagged and tattooed), then entered into the system (desktop computer or HHC). The steps included in the timing process for arrivals are tagging and data entry. Tattooing is not included

because it is performed differently under each system based on personal preferences of the unit managers, the difference is not related to the type of system used.

Tagging: All units tag their new arrivals with one regular ear tag. The only exception to this is the unit which uses the EID system. In this system, in addition to the regular ear tags, the sows are also tagged with an ETT.

Data entry: This is the most important task in this event since it accounts for the greatest difference in time between the systems. The MS enters the information for the new arrivals in batches of 100 gilts at a time into the desktop computer of the unit. As for the HHC and EID systems, they enter the new arrivals' information on an individual basis. This is done in the unit using the EID system so that the regular ear tag numbers are correlated to the transponder code of the ETT attached to the sow's ears.

The Manual System

Tagging: The animals are placed in individual crates upon arrival. Three technicians are involved in the tagging, with one technician performing the actual tagging, one preparing the tagging gun, and the third controlling the gilt.

The SW is started when a technician starts loading the tag gun and is stopped when the ear tag is in the ear.

Data entry: The information for the new arrivals (birth date, breed, arrival date, etc.) is entered into the unit's desktop computer in batches of 100, where information for 100 new arrivals is entered at a time. This is done by one technician and usually does not take more than a couple of minutes.

The SW is started when the technician begins to manually type into the computer the range of tag numbers of the new arrivals and is stopped when the same technician removes his/her hands from the keyboard.

The Hand-Held Computer System

Tagging: The animals are placed in pens of 8-10 gilts. Two technicians are involved in the tagging process—one technician prepares the tag and the other loads the tagging gun and then tags the animal.

The SW is started when the technician is handed the tag and starts loading the tagging gun and is stopped when the ear tag is in the ear.

Data entry: The new arrivals' information is entered individually into the unit's desktop computer, not into the HHC.

The SW is started when the technician begins to type the sow ID (which is the first item of information typed into the computer) and is stopped when he/she moves on to the next sow ID.

The Electronic Identification System

Tagging: The animals are placed in pens of 8-10 gilts and snared during tagging. Snaring is done for two purposes: (1) because the tags are reusable, the tags are placed away from the thinner, outer edges of the ear to avoid the tag from being torn off, and (2) for tattooing purposes. Three technicians are involved—one prepares, one snares, and the third tags.

There are two parts to the this task—preparing the gun and tagging. These parts are timed separately and then added together. First, the SW is started when the technician preparing the tagging gun starts to load it, and is stopped when he/she is done loading. Second, the SW is started when the technician, who is tagging, receives the prepared gun and is stopped when the tag is in the ear.

Data entry: One technician enters the data of the new arrivals into the HHC. While the new arrivals are being tagged and tattooed, he/she enters the tag number into the HHC and then scans the corresponding ETT with the wand. This assures that the regular ear tag number, which is manually entered into the HHC, and the ETT code correspond. The necessary data (data, breed, etc.) are entered into the HHC.

> *The SW is started when the technician looks down to read the regular ear tag number to enter it into the HHC, and is stopped when he/she is done entering the information.*

Breeding

Sows and gilts that are found in heat (assuming a rigid, immobile, receptive stance, the standing reaction, or locked position) are serviced three times (X1, X2, X3). When all the breeding for the day is done, the sows in heat are moved to predesignated pens in the gestation barn. These pens are organized according to breeding dates and are referred to as "The Snake." The sow ID number and service information are entered three times into the data system for each breeding or mating (X1 + X2 + X3 = one mating). The unit using the HHC system does not enter X3, by choice. Even though observations were collected for all three services in the other units, only the X1 and X2 observations were used in the statistical analysis. This means we underestimate the actual time savings or loss occurring in the units under each system.

The Manual System

Each service includes two steps—creating an on-site list or form regarding the breeding information, and then entering that information from the form into the desktop computer. This is done twice, once for each serving.

Making a list: This involves one technician moving along The Snake and making a list with the sow

ID, the boar ID, and, if the sow is artificially inseminated (AI), then the breeder's ID is also included.

The SW is started when the technician reads the sow's breeding card and is stopped when he/she has written down the sow's information and moves along to the next animal.

Entering the list into the desktop computer: The form is taken into the office and the

information is entered into the desktop computer.

The SW is started when the technician starts to read the information from the form and is stopped when he/she has entered the information for that individual sow.

The Hand-Held Computer System

After the bred sows are placed in The Snake, a technician takes the HHC to the barn and

enters the sow's tag number of the bred animal and then enters the breeding information directly

from the sow's breeding card. There is no need to make a form under this system.

The SW is started when the technician stands behind the sow and begins entering the sow's ID number and is stopped when he/she is done entering the information for that individual sow and moves to the next sow.

The Electronic Identification System

Here it is the same as using the HHC, but the technician uses the wand to scan the ear tags

instead of entering the sow's ID manually.

The SW is started when the technician reaches out with the wand to scan the ETT and is stopped when the technician has entered the sow's information and moves to the next sow.

Farrowing

Sows are transferred to the farrowing houses 3-5 days before their expected farrowing dates.

Sows farrow at an average of 2.5 times per year with an average litter of 9 piglets. The farrowing

information—born live, stillborns, and mummies—is recorded onto the back of the sow's breeding cards and then entered into the data system. The farrowing event was timed during the spring of 1997 when the MS had already been eliminated at the 5,000-sow units, therefore the only two systems that were analyzed were the HHC and the EID systems.

The Hand-Held Computer

Each morning, the data technician goes through the farrowing houses and enters the sow's ID number, farrowing information, and the location of the farrowed sows into the HHC. He/she then makes a printout of this information, which the other technicians use to locate the sows. There is only one task in the recording process of this event, which is the time that the designated technician needs to enter the sow's ID and farrowing information into the HHC.

> *The SW is started when the technician reads the farrowing information from the sow's card and is stopped when he/she has entered the information and moves along to the next sow.*

The Electronic Identification System

This is very similar to the recording process of the HHC system. The technician steps into the crate to scan the ear tag and enters the farrowing information into the HHC.

> *The SW is started when the technician steps into the crate to scan the ear tag and is stopped when he/she has entered the information and moves along to the next sow.*

Weaning

Piglets are weaned when they reach the average age of 3 weeks. Then they are shipped to nurseries, and the sows are taken back to the breeding barns to be bred again. This event was also timed during the spring of 1997, like the farrowing event, where the HHC and the EID systems were the only systems timed and compared under the weaning event.

The Hand-Held Computer

The night before the piglets are shipped out a technician takes the HHC and enters the sow ID, number of piglets weaned, and the sows condition into the HHC.

The SW is started when the technician reads the sow's card and is stopped when the technician has entered the weaning information and moves to the next sow.

The Electronic Identification

This is very similar to the HHC system. The technician steps into the crate and scans the tag and enters the weaning information.

The SW is started when the technician steps into the crate to scan the tag and is stopped when he/she has entered the weaning information.

Culling

Animals are culled when they are found to be less productive or of low performance. These animals are flagged with "Cull Sow Cards" on which the reasons for culling are recorded. Culls are trucked off the unit usually once or twice a week. Because the ETTs are reusable, the recording process for the EID system includes the time necessary to remove the ETTs in addition to entering the culling information into the system. While the tags used in the MS and HHC systems are disposable, the only tasks included in the recording process are those which involve the culling data only.

The Manual System

Making a list: The coordinator makes a list of culled sows the day before the culls are shipped out of the unit. This list is a guide for the workers who will load the cull truck.

The SW is started when the technician reads the information on the sow's cull card and is stopped when he/she has recorded the information on the cull list.

Data entry: The cull list is then entered into the desktop computer on the day the animals are shipped out.

The SW is started when the technician reads the list and is stopped when he/she has entered the information for that particular sow into the desktop computer.

The Hand-Held Computer

There is only one technician who enters the culling information directly into the HHC on site.

The SW is started when the technician starts to read the sow's ID, either off the ear tag or from the sow's cull card and is stopped when the technician has entered the information and moves to the next culled sow.

The Electronic Identification System

Three technicians are involved—while one scans the ear tag and enters the data into the HHC, another controls the animal, and the third removes the ear tags.

Data entry: The ETT is scanned and the reason for culling is entered into the HHC.

The SW is started when the technician reaches out with the wand to scan the ETT and is stopped when he/she has entered all the culling information.

Tag removal: Since the ETT can be reused, the ear tags are removed from the sow's ear.

The SW is started when the sow is under control and is stopped when the tag is removed.

Appendix B: Statistical Analysis Results

A statistical analysis was done using the SAS program. Linear combinations were used in our statistical calculations. The variances of the linear combinations were also calculated. The means and variances of the tasks within each event were summed together. We compared the same events across the units with a 95% confidence interval.[11]

We then combined the times for the events for each unit and estimated the time spent in the recording process under each system in a sow's lifetime. We took into consideration the number of times each event took place in a sow's lifetime. Arriving and culling occur only once. Farrowing and weaning were calculated under the assumption that each sow has 7 parities throughout her productive lifetime (a target of 2.5 parities per year). The estimated average percentage of rebreeds across the units in C4F is 15%. The breeding calculations included this 15% rebreeds, therefore, each sow is bred at an average of 8.5 times over her productive lifetime.

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[11]The number of observations collected in each task was different, therefore, the degrees of freedom associated with the task that had the smallest number of observations was used when calculating the confidence intervals. When the degrees of freedom was very small, the weighted *t*-value was used.

Gilt Arrival Data—Results For All Systems

The Manual System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Tagging[12]	37	11.6962162	4.6917507	5.4200000	26.2600000
Entering[13]	2	1.0250000	0.1767767	0.9000000	1.1500000

The Hand-Held Computer System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Tagging	34	16.5794118	8.5732487	6.5600000	49.2600000
Entering	100	5.6150000	2.1828239	3.1400000	15.5100000

The Electronic Identification System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Pretag	36	5.1194444	1.6385010	3.2600000	12.7900000
Tagging	36	4.4677778	5.5580840	2.0400000	36.2500000
Entering	29	24.9482759	3.9104951	19.1700000	37.7200000

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[12]This was adjusted for the number of technicians involved (multiplied by 1.5).

[13]Two available observations were taken of new arrival information and entered in batches of 100. The actual averages were divided by 100 to obtain an average on a per-sow bases. Because the degrees of freedom is very small, the weighted *t*-value was used when making the calculations.

Summer Breeding Results Under All Three Systems

The Manual System

Variable[14]	N	Mean	Std. Dev.	Minimum	Maximum
List 1	83	12.9556627	3.7249417	6.4400000	23.6800000
Enter X1	91	14.7746154	5.2754522	5.6200000	34.4800000
List 2	50	10.0326000	2.8463237	5.5300000	20.4400000
Enter X2	90	8.9643333	2.7760286	5.0200000	18.4000000
List 3	34	10.1261765	3.3585567	5.7400000	20.7600000
Enter X3	48	11.9731250	4.8698098	5.3700000	23.8500000

The Hand-Held Computer System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
X1	67	17.5531343	6.4859429	8.7100000	49.3700000
X2	91	13.5486813	5.1504641	7.1700000	34.7600000

The Electronic Identification System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
X1	51	18.9101961	5.5772005	10.3800000	31.3600000
X2	46	18.9873913	7.9064653	6.6400000	42.1000000
X3	52	17.4940385	7.8144522	9.2900000	55.5200000

[14] Each mating (breeding) is made up of three services; X1, X2, X3.

Spring Breeding Results for the Two Automated Systems Only

Variable	N	Mean	Std. Dev.	Minimum	Maximum
HHC X1	53	9.8332075	2.1092623	6.9900000	17.6100000
HHC X2	89	11.4149438	1.6631871	8.5000000	17.8500000
HHC X3	64	10.7859375	2.1077790	1.5000000	16.6200000
EID X1	79	7.8439241	1.5414998	5.1600000	14.5300000
EID X2	60	8.8866667	2.1299564	6.2400000	17.5100000
EID X3	95	9.2547368	2.5539127	6.1600000	18.3100000

Farrowing Results for the Two Automated Systems (HHC and EET)

Variable	N	Mean	Std. Dev.	Minimum	Maximum
HHC Sys.	89	17.5857303	2.1685148	14.2500000	28.7200000
EID Sys.	73	14.3034247	3.0154639	9.1800000	21.0800000

Weaning Results for the Automated System (HHC and EID)

Variable	N	Mean	Std. Dev.	Minimum	Maximum
HHC Sys.	206	10.3067961	1.5181405	7.4100000	16.6900000
EID Sys.	211	10.5005687	2.2875239	6.1200000	19.0500000

Culling Data Results for all Systems

The Manual System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
List	65	7.2401538	3.3026010	2.1500000	16.5700000
Entering	35	5.2257143	3.7644844	2.2800000	18.4000000

The Hand-Held Computer System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Cull	89	6.8075281	2.2597658	4.0100000	15.4900000

The Electronic Identification System

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Tagging[15]	51	9.5609804	3.4214192	3.5100000	18.0000000
Entering	153	10.8725490	3.9191290	5.1600000	24.9500000

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[15] This is adjusted for the number of technicians involved (multiplying the number by 2).