

THE QUALITY OF TASK TIMES:A METHODS RESEARCH

Marianne van der Schilden

Institute of Agricultural and Environmental Engineering (IMAG-DLO)

Labour Management and Ergonomics Department

P.O. Box 43, NL-6700 AA Wageningen, the Netherlands

Phone: (+31) 317-476463

E-mail: M.vanderSchilden@IMAG.DLO.NL

Abstract

IMAG-DLO is faced with large demands for labor data in spite of limited research capacity. Consequently IMAG-DLO is greatly concerned for the efficiency of the methodology used in task time synthesis, with even greater concern for maintaining the quality of the estimates of task times. Much effort has gone into determining the optimum method for collecting, computing, and storing labor data, the so-called task time synthesis. Task time synthesis can be achieved by four different procedures. These are, in order of decreasing accuracy, Predetermined time systems, Time study, Time registration, and Time estimation. These procedures are illustrated by a schematic overview and described. The applicability of the four procedures differs in horticulture depending on the research goals. The goals of labor management research focus on the evaluation of new developments in practice. Predetermined time systems are very time consuming and less suitable for the variable circumstances in horticulture. Time studies are most recommended as they appear to have the best price/quality relation for task time synthesis. Time registration delivers more indicative than normative task times, and Time estimation is very inaccurate and only to be applied when no other procedure is possible. Finally a protocol for this new direction in labor management research is described.

Key index words

Operation, Work study, Time study

1. Introduction

In western areas government research priorities have given greater emphasis to issues such as the environment and working conditions and less attention to labor management. The main consequence of this policy is that few labor management specialists are available for research or active in collecting labor data in practice.

In the Netherlands this means that the labor department of IMAG-DLO has a limited critical research capacity, and research stations offer even less labor specialist capacity. Other countries that used to do substantial research in the field of labor management (like the USA, Germany, the UK, Denmark, Sweden, Norway, etc.) have the same financial and research capacity problem. This calls for international cooperation such as sharing labor databases. In the 'XXVI International Congress in Work Science' which was held in 1995 in Norway, the participating countries agreed upon the development of an international labor database. The ISHS Working Group 'Labor and Management' organized this congress together with the CIGR-V and the CIOSTA. Cooperation with these agricultural groups with similar interest in labor management is beneficial. The lack of interest from the policy makers may only be temporary for there is evidence of great demand for labor data. Demand comes from growers, extension, insurance companies, other fields of research (labor conditions, management) and horticultural policy makers. Because of the increasing interest in labor conditions and automation, the demand for labor data by research and policy makers is reinforced. Normative labor data are the basic input for the whole field of labor research.

Labor management research delivers labor demand figures in the form of "task times" per operation. A task time is defined as *the time expressed in man-hours or man minutes per unit, required for the complete performance of an operation or chain of operations under given working conditions and work method*. IMAG-DLO has great concern for the efficiency of the methodology used for task time synthesis, with even greater concern for keeping the quality of the task times. Much effort has been directed to the optimization of the method of collecting, computing, and storing of labor data, the so called task time synthesis. Also special task times models are developed at IMAG-DLO (Achten ea., 1995). In this paper only the results of the methods research are summarized. The different procedures for task time synthesis are described, followed by the applicability of the procedures in horticulture and the protocol for labor management research.

2. Description of the methods for task time synthesis

The collection of basic data prior to the calculation of the task times is called task time synthesis. Different methods of task time synthesis have been developed over a long period of time (from ca. 1800). Within these several methods a great diversity of approach and calculation method appears. Some methods and procedures are described by Whitmore (1970) and Barnes (1980). The procedures that proved to be useful have been implemented and applied in horticulture. Much time and quality in estimates was lost, however, by the lack of a clear and accurate description of the entire computing method. The resulting variability in methodologies also made it difficult to model the process of task time synthesis, to cooperate with other labor management specialists or to share databases with other institutions or countries. Therefore, a clear description is needed containing calculation protocols, unambiguous definitions of labor management terms and directions for the interpretation of the tables for rest allowance and the work rate schedule (Van der Schilden, 1990a).

The four main procedures within the method of task time synthesis are schematically reflected in Figure 1. These can be found at the top of the scheme, namely Predetermined time systems, Time study, Time registration, and Time estimation. The left side of the scheme refers to the level of detail to which an operation is analyzed. An operation can be divided into work elements or the motions that determine the work element (table 1).

Table 1. Scheme of different levels of labor study with practical examples.

| Level | Example | Time indication | Time unit |
|----------------|--------------------------------------------------|-----------------|-----------|
| motion element | walk a pace (W-P) | 15 | TMU* |
| | Reach over 45 cm, to a separate object (R45B) | 17 | TMU |
| | Grasp with simple grip (G1A) | 2 | TMU |
| work element | pick four tomatoes | 8 | cmin** |
| | put aside four tomatoes | 4 | cmin |
| | move cart, once per plant | 12 | cmin |
| operation | picking of tomatoes with cart, per path | 18 | minutes |

* TMU = time measurement unit, 0.00001 hour **cmin = centiminute, 0.01 minute

In Figure 1, the executed calculation formulas are printed in italics. The meaning of all terms used will be explained by discussing the four procedures in sequence.

2.1 Predetermined time systems

The most detailed systems for task time synthesis are the Predetermined Motion Time Systems (PMTS). In these systems, work elements are divided into single motions. For each motion, a time is set depending on the type of motion and the circumstances under which the motion has to be carried out (e.g. distance, weight). These identified motion times are listed in special tables. A very detailed analyses of the operation is made, in which motions that occur simultaneously, are taken into account (e.g. sorting tomatoes with both hands). The *motion times* are gathered from the tables, multiplied by their frequency of occurrence and added to compose a *standard time* for the work element. Hereafter, the standard times of the different work elements are multiplied by their occurring frequency and added for the *task time*. If necessary, allowances are added to calculate the resulting task time (allowances refer to extra time that has to be spent but is not included in the pure working time). In the motion time tables of most PMTS some extra time for recovery (rest time) is already included, so no rest allowance has to be added in the last phase of the synthesis. Examples of these PMTS are Methods Time Measurement (MTM1) and Work Factor. To simplify the analyses, shortened PMTS have been developed in which the number of distinguished motions is reduced by combining several motions to new ones, called actions (e.g. Get = Reach + Grasp + Move) and put down, as **action times**, in compressed tables. Examples of these, less detailed, PMTS are MTM2,3 and Elemental Times for Agriculture (ETA). ETA has been developed by IMAG-DLO for agricultural work (Liem ea., 1967) and is used in different countries (Luxhoj ea., 1990).

Another, less detailed, system of using predetermined times is to set a time for all standard work elements that occur in horticulture (e.g. transport, transshipment, stacking, picking of tomatoes) and list these, so called *basic time elements* in an archive. These basic time elements can be set by PMTS and checked by time measurements in practice or they can be the result of a great number of time studies. Because of the long history of collecting labor data IMAG-DLO maintains an extensive basic time elements archive. This archive is used when task times are calculated in the task time models that are developed by IMAG-DLO.

2.2 Time study

The labor specialist observes and measures the elemental times with a timing device to determine task time. When the work speed of the observed worker deviates from the standard speed, speed ratings can be given to standardize the performance. A standard speed for each type of work is defined (Cloudt et al., 1993) and the observed speed is rated at the IMAG-work-speed-schedule (Van der Schilden, 1990a). When possible over a hundred *measured times* are used per element so the average *elemental time* is statistically reliable. By multiplying the elemental times by the speed rating and dividing these by the standard speed they become *converted elemental times*. The average of the converted elemental times from a number of time studies make the standard time per work element. The standard times are multiplied by the occurring frequency of the element within the operation and added. To complete the *task time*, allowances are added like 'rest and personal care and disturbance'. For determination of the rest allowance (including personal care allowance) special tables are used. The scientific basis of these tables is in dispute, and therefore the figures are arbitrary IMAG-DLO is doing research on a better way to deal with the rest time needed. Research from Wildt (1992), however, supports the use of the old rest allowance tables for the time being. For disturbance time a fixed percentage is added for manual horticultural work, determined by the basic time archive of IMAG-DLO.

2.3 Time registration

This method involves the workers' recording the actual work time for a list of well defined operations after every two hours of work either by hand or on electronic devices like hand-held computers. All occurring operations are registered for at least one week. The *registered times* are standardized per operation for a fixed production level (potting of 100 pots, picking of one bay of tomatoes) and the average of all registered times collected makes the *task time*.

2.4 Time estimation

Rough labor data may be determined by estimation by labor specialists with sufficient experience and knowledge of the practical situation. These experienced labor specialists are able to interpret sector specific information from handbooks and other historical data and compose a rough task time. The estimation can also be supported by verbal information from the growers who know the approximate amount of hours spent on certain operations. Sometimes estimation is the only way to develop task time values. For instance estimation is appropriate when a labor budget of a hypothetical growing system is composed or for highly variable operations like management, maintenance and cleaning.

3. Goals of labor management research in horticulture

The goals of the research will determine the application of the task times retrieved and the level of detail and accuracy needed.

The demand for task times can originate from the following aims:

- Task times with a *low* accuracy are needed for very variable operations, in order to complete a labor budget.
- A healthy flow of up-to-date task times is needed for the update and extension of the horticultural labor databases that IMAG-DLO conducts. These times are used as input for the task time models and the labor databank. With these models, complete farm specific labor budgets are calculated and a *medium* accuracy is preferred.

- For the development of new machines or automation, for the production of new crops or for new production methods of familiar crops, specific and detailed labor data are needed to predict the financial consequences as well as the changes in labor conditions (*medium and/or high accuracy*).
- For the evaluation of new developments as they are tested or newly applied in practice, E.g. calculation of the financial advantage of new machines. Different types of machines may be produced. Labor data of a *high* level of accuracy are needed to make calculated judgements of the advantages and disadvantages of each type. This helps manufacturers to improve their machines at these points, and it informs the growers about what machine will fit best in their nursery. With the task times a break-even point can be calculated that helps the growers to decide at what production level it is profitable for them to invest in this new machine.
- In horticulture task times with a *very high* accuracy are normally not demanded.

The main interest for labor data is changing from the medium to the medium and high accuracy level. Because at present, most labor research questions refer to the development and evaluation of new machines or transport systems, handling of the culture of new products (e.g. culture of tomatoes on the vine) or new growing systems for familiar products (e.g. growing cucumbers on a high wire).

4. Evaluation of the applicability of the methods in horticulture

Research has been performed by IMAG-DLO on the applicability of each of the procedures described.

4.1 Predetermined time systems

The advantages of PTS are that all information is objective and detailed and therefore reproducible and transmittable. Hypothetical operations can also be analyzed by PTS e.g. for models of new growing systems (Giacomelli et al. ,1987). The resulting task times are of a very high or high accuracy. The major disadvantage of PMTS is that analysis is very time consuming. Labor specialists need to have much experience with MTM1 and knowledge of the work situation in practice. Use of MTM1 is not recommended in horticulture, because the working circumstances are too complicated and variable to divide into standard elements due to the nature of the product. The labor specialist can easily forget small movements like pushing the vine aside when picking a cucumber. Use of MTM1 is possible however when industrial type of work is analyzed like transport and potting with a potting machine.

PMTS like MTM1 and Work Factor as well as the basic time archives are PTS with the same advantages except that the basic times are less accurate, depending on their origin. Use of basic time elements is very efficient as long as the archive is conducted well and all information about the working circumstances is thoroughly described. Therefore the basic times archive of IMAG-DLO, containing the large historical labor database of horticultural operations, is very valuable.

4.2 Time study

Task time synthesis by performing time studies in practice is the most recommended method for most horticultural operations. The main advantages are that task times are conducted with a high accuracy level, and the observer is not likely to forget work elements. A disadvantage of time study is the subjectivity of parts of the measuring procedure, primarily the rating of the work speed. Analysis of work by time study is time consuming, so it should be applied mainly for the most important operations. A good preparation before performing time studies is described in the

protocol for labor study later in this paper.

4.3 Time registration

The advantage of time registration by workers is that data are quickly available for many operations at the same time. The greatest disadvantage is that detailed information is missing. In the first place, there is a great risk of difference in interpretation of the named operations by different nurseries. Descriptions of operations are too vague and the working circumstances that have a significant influence on the recorded labor times are not clear (like diseases in the crop, fruit weight etc.). There is no insight into the work speed of the workers. The variation in recorded labor figures has proved to be high, and therefore the reliability is low. The resulting data are more indicative than normative.

4.4 Time estimation

Estimation should only be performed by specialists who have great experience in labor management as well as knowledge of the practical situation in the sector. It may only be used when no other data are available, when data can not be obtained in any way or when a very low level of accuracy is needed. Examples where it can be appropriate to estimate are the labor demand of crop protection, biological control of diseases, or maintenance.

5. Concluding protocol for labor management research

The following protocol for labor management research is recommended as being the most efficient, with the best price/quality relation for the obtained task times.

- 1) The whole sector is described with all occurring and necessary operations. When the question is referring to only a special type of nursery a firm specific budget is composed. A list of all operations needed, divided into elements is conducted as basis for the resulting labor budget.
- 2) At this point the so called 80/20 rule is applied. Approximately 20% of the operations are responsible for 80% of the total labor demand. To figure out which 20% of the operations cover the main 80%, an estimated labor budget has to be composed. Labor specialists use their experience and basic time archives of similar elements to fill in these rough labor data.
- 3) Labor databases and literature are checked thoroughly for elements in which the labor data are already available in task time databases or *basic time archives* (PTS). Data for the same or very similar elements which have the needed accuracy can be copied. A list of unknown or maybe even new operations with their elements is identified. For example, for the harvesting of tomatoes, a new type of transport unit has been developed that is emptied by opening a valve in the bottom. The labor needs of all elements have been measured and calculated, except for the element 'empty the transport unit in the main path.'
- 4) The labor need for all elements of the 20% main operations should be determined at a high level of accuracy, preferably by performing *time studies*. Elements that are part of the other 80% minor operations are measured as well when they occur while the observer is at the nursery. Elements that are already filled in with times from the labor databases may be measured to check their validity. The gain in reliability of the results is considered against the costs of the extra effort needed. When it is not possible to make time studies, an accurate *PMTS* system can be used for determination of the most important elemental times.
- 5) Accurate times of all elements of the 20% main operations are collected and most of the other elements are determined as well. The labor need for the remaining less important elements can be established at a medium or low level of accuracy. The experience of the growers and the labor

specialists can be used for *estimation* of the labor need and these estimations are compared to labor data of similar operations to check their validity.

At this point a complete labor budget is ready for use, depending on the research question. While developing a new machine or growing system, redundant labor input is slowly minimized by work method improvement for which the labor budget forms the basis.

Work method improvement studies should be done on four levels of increasing impact. When improvement on the first level is not possible, continue onto the second, then to the third, and in the last instance try to improve on the fourth level (Van der Schilden, 1990b). The work method improvement levels are: 1) skip the operation, 2) mechanize, 3) use a tool/device and 4) change the manual task. New time studies have to be performed after the improved operations are implemented in practice.

6. Discussion and future research topics

The quality of the task times is influenced by several steps in the synthesis. Extra attention is put to each of these determining aspects, and research projects have been defined in order to guarantee the highest possible reliability at the lowest costs. In this paper only the main processes have been described to put the influential aspects in perspective. The main research items within the task time quality research project of IMAG-DLO are: defining standard work speeds, calibration of work speed rating (finished in 1996), theoretical basis of rest allowance tables, deviation in measuring techniques, deviation between time study observers. The main objective is to develop an efficient method to deliver task times of a suitable quality. One of the most important appliances of the gathered times is to supply input data for the task time models and the international labor databank.

References

- Achten, J.M.F.H., Kroeze, G.H. 1995. Application of tasktime models and databases. Lillehammer, Ciosta/CIGR/ISHS, proceedings of the XXVIth International Congress in Work Science, Norway.
- Barnes, R.M. 1980. Motion and time study. Design and measurement of work. New York, John Wiley & Sons.
- Cloudt, M.; Schilden, M. van der. 1993. Definitie van werksoorten [Definition of work types]. IMAG-DLO nota P 93-69. Wageningen, Netherlands.
- Giacomelli, G.A.; Weel, P. van; Schilden, M. van der. 1987. Expert systems development for greenhouse potted plant production. American Society of Agricultural Engineers, paper no. 87-5012. Baltimore, MD.
- Liem, T.L.; Gerritsen, J.G.C. 1967. Elemental times in agriculture. N.A.A.S. Quartely Review, 77, p38-46.
- Luxhoj, J.T.; Giacomelli, G.A. 1990. Comparison of labor standards for a greenhouse tomato production system: a case study. International Journal of operations and production management, 10 (3): 38-49.
- Schilden, M. van der. 1990a. Ontwikkeling methode taakanalyse [Development of a method for task time synthesis]. IMAG-DLO nota 472, Wageningen, Netherlands.
- Schilden, M. van der. 1990b. Improvement of working methods in the culture of crops to be harvested in one operation. Wageningen, IMAG-DLO report 234, Netherlands.
- Whitmore, D.A. 1970. Work study and related management services. London: UK. William Heinemann Ltd.

Wildt, U. 1988. Belastung und Beanspruchung des Menschen bei gartenbaulichen Arbeiten und hieraus resultierenden Erholungszeiten [Work load of humans performing horticultural labor and resulting rest allowances]. Universität Hannover, dissertation 65, Hannover, Germany.

Figure 1. Scheme of the different procedures within the method for task time analyses and their coherence.

