Work Study Nomenclature and Protocols: A Literature Review

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Summary

Work study can be defined as the “systematic examination of the methods of carrying on activities so as to improve the effective use of resources and to set up standards of performance for the activities being carried out” (Kanawaty, 1992). Work study is a broad term composed of several techniques but predominantly of method study and work measurement. Time study is a technique that can be applied in many different work situations where the human element is involved. In a general sense, time study is an effective tool to investigate, reduce, and possibly eliminate ineffective time, the time where no effective work is performed (Kanawaty, 1992). Specifically in forestry, time study data can be used to rationalise production (Björheden, 1991). Time study is used in forestry with four goals in mind; to improve work organisation and planning, control and follow-up on operations, improve and compare working methods, tools, and machinery; and create data for performance and cost calculations (Björheden, 1991).

Various glossaries and nomenclatures on general work study and forest work study terminology exist in literature. A standard forest work study nomenclature is necessary because it is the first step to developing a standard forest work study methodology (Björheden and Thompson, 1995). Various models can be found in the literature. Presently, the European Cooperation in the field of Scientific and Technical Research (COST) is currently working on Action FP0902: Development and harmonisation of new operational research and assessment procedures for sustainable forest biomass supply. The COST Action is formally investigating existing terminology relating to forest biomass for energy; work study methodologies and standard biomass measurement approaches; costing assumptions and data analysis methods; and systems analysis and modelling approaches in forest operations (COST, 2009). Additionally, Australia’s Cooperative Research Centre for Forestry (CRC) has developed standard study methods and forms for forest work studies to be conducted with, specific to the operating parameters and conditions in Australia (Brown et al., 2010).

This review concludes that no formally accepted work study protocols or updated nomenclatures exist. However, the development of a completely new protocol and glossary seems unnecessary as there are existing protocols and nomenclatures that can be adopted or have value added. South Africa can adopt existing protocols and glossaries to be used as its standard. Furthermore, working in co-operation with other forest research agencies, in the form of funding and other resources could result in the creation of a standard for the southern hemisphere.
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Introduction and History

Work study can be defined as the “systematic examination of the methods of carrying on activities so as to improve the effective use of resources and to set up standards of performance for the activities being carried out (Kanawaty, 1992). This field includes the study of technical, psychological, physiological, social and organisational aspects of work (Rickards et al., 1995). Work study is a broad term composed of several techniques but predominantly of method study and work measurement. Method study is a critical and systematic examination of ways of doing work in order to make improvements (Kanawaty, 1992; Rickards et al., 1995). Work measurement applies different techniques, including time study, to establish the time for a qualified worker to carry out a specific job at a defined level of performance (Kanawaty, 1992; BSI, 1959). Time study is one of the most important work measurement techniques and its principle aim is to critically analyse time consumption of work elements to increase efficiency (Rickards et al., 1995). Various techniques such as a check study, activity sampling, or a productivity study can be carried out in conjunction with a time study to further study productivity and efficiency (Rickards et al., 1995).

The general agreement is that Frederick W Taylor was the originator of the time study concept in a machine shop in 1881 (Barnes, 1963). According to Taylor, time study was a method beyond all others to “transfer [skill] from management to men” (Barnes, 1963). Time study addresses the procedures for determining a standard amount of time required, under certain conditions of measurement, for tasks which involve some human activity (Mundel, 1978). Taylor divided time study into two parts; analytical work and constructive work. Analytical work included dividing the work into elementary movements; studying, with the aid of a stopwatch, the best time and method for making each elementary movement; describing and recording, with time, each elementary movement (Barnes, 1963). Constructive work includes: adding together groups of elementary movements frequently occurring in the same sequence; select the proper sequence of motions and find the proper time for doing the work; analyse the work sequence to find defective conditions (Barnes, 1963). With the advancement of technology, time study data collection methods are shifting away from the use of stopwatches and paper towards portable electronic devices loaded with work study software to collect time elements.

There are various methods of timing commonly used for time studies including: snap-back (also: repetitive or fly-back), continuous, selective, and differential (Rickards et al., 1995; BSI, 1959). Snap-back timing refers to a method where the stop-watch or timing device resets to zero at the end of each work element (Rickards et al., 1995). Continuous timing occurs when the timer is not reset to zero after each element and the element times are obtained through subtraction (BSI, 1959). Selective timing is another method which does not reset the timing device to zero after each element. Differential timing obtains times for short duration, or small elements. A group of elements is timed with and without the small element, and subtraction is used to determine the small element time (BSI, 1959).

The time recorded in time studies is considered to be observed time and can be related to the standard time, or the average time expected for a job to be completed (BSI, 1959). To determine
standard time, a performance rating is applied to the observed times. Standard time is then the conversion between a quantitative statement of workload to a quantitative statement of required input resources (Mundel and Danner, 1994). It has, however, been suggested that subjective performance rating systems should not be applied to time studies on forest operations (Björheden, 1992; Samset, 1988). Due to the non-homogenous conditions of forest operations and the variability of man and machine steered work, the errors in estimating these factors can be rather large (Samset, 1988). As a result, subjective performance ratings are not generally used in conjunction with scientific time studies (Samset, 1988).

Time study is a technique that can be applied in many different work situations where the human element is involved. In a general sense, time study is an effective tool to investigate, reduce, and possibly eliminate ineffective time, the time where no effective work is performed (Kanawaty, 1992). Specifically in forestry, time study data can be used to rationalise production (Björheden, 1991). Time study is used in forestry with four goals in mind; to improve work organisation and planning, control and follow-up on operations, improve and compare working methods, tools, and machinery, and create data for performance and cost calculations (Björheden, 1991).

Nomenclatures and Time Models

Various glossaries and nomenclatures on general work study and forest work study terminology exist in literature. The different glossaries all aim to provide a standard work study nomenclature. However, at this point, there is no internationally agreed upon standard work study nomenclature, although there are a few glossaries that are most commonly cited. A standard forest work study nomenclature is necessary because it is the first step to developing a standard forest work study methodology (Björheden and Thompson, 1995). A standard nomenclature will facilitate information sharing and provide a basis for comparison of studies done around the world.

Time models are used to show how different time concepts are structured and related. These models break down ‘total time’ (the total elapsed time of the period under consideration – also calendric or control time) into more specific time components which vary depending on the nomenclature used. Various models can be found in the literature including those developed by the BSI, NSR, IUFRO, Australia’s CRC, Canadian Pulp and Paper Association (CPPA), Forest Engineering Research Institute of Canada (FERIC), Skogforsk (StanForD time model), and a very basic model can be found in the ILO’s work study publication (Kanawaty, 1992).

British Standards Institution

A well cited glossary is the British Standard 3138: Glossary of Terms in Work Study. This glossary is used as a foundation for defining terms by International Union of Forestry Research Organizations (IUFRO), International Labour Organization (Kanawaty, 1992) and the British Forestry Commission. The British Standard Institution (BSI) recognised the need for a common technical language and defines terms relating to both method study and work measurement. Time study is one of several work
measurement techniques defined in this glossary, the others include synthesis, predetermined motion
time system, analytical estimating, estimating, activity sampling, and rated activity sampling. This
document considers the determination of standard time as the end goal of work measurement (BSI,
1959). The 0/100 British Standard Scale is used to convert observed time to standard time. The
Appendices define terms in related fields to work study and include sections on Labour Control, and
Plant and Machine Control. These two sections provide definitions for time concepts leading to the
development of two explanatory diagrams of labour control and machine time (BSI, 1959).

BS 3138 provides two time concept models, one for machine time (Figure 1) and one for labour
control (Figure 2). Under the labour control time model, delays, or non-working time, can fall under the
categories of diverted time or waiting time. Diverted time is time lost to non-productive activities such
as meetings or accidents (BSI, 1959). Waiting time is further separated into Department Responsible
and Department Not Responsible time (BSI, 1959). All the time concepts defined are not limited in
length by the measured time, meaning each time concept could last for any duration within the total
time constraint. Unlike other models, the BSI includes authorised relaxation as a part of working time
and not as a delay or non-work time activity.

![Explanatory diagram of machine time concepts (BSI, 1959).](image)

**Figure 1.** Explanatory diagram of machine time concepts (BSI, 1959).
Figure 2. An explanatory diagram of terms for labour control (BSI, 1959).

Nordic Forest Study Council

In Scandinavia the most commonly used nomenclature is the Nordic Forest Study Council’s (NSR) Forest Work Study Nomenclature. This nomenclature defines basic concepts and terms; shows how time is divided; how time can be recorded (time registration methods), and it also describes concepts related to machine utilisation and availability (NSR, 1978). The NSR recognises the difficulty and subjective nature of applying performance ratings to forest work, and as a result, it does not use performance ratings or address the concept of standard time. Simple formulas to find machine availability and utilisation are provided as well. A concept which is unique to this nomenclature is gross effective time (E_t). According to this concept, if a rough method of time registration is used in practical time studies then delays shorter than the rough time registration accuracy are included in gross effective time (NSR, 1978). For example, if the timing accuracy is ten minutes, then delays less than ten minutes are
included in $E$. This allowance could result in inaccuracies when estimating effective time and is one of the main issues IUFRO has with this nomenclature (Björheden and Thompson, 1995). Another criticism is the allowance of subjective determination of whether delays are avoidable or not (Björheden and Thompson, 1995).

NSR’s time model is based on the following time concepts; work time, task time, element time (direct and indirect), and quantity and period dependent times (Figure 3). Times can be direct or indirect, that is, directly changing the work object in form, position or state, or not (NSR, 1978). Times can also be fixed or variable, depending if they vary based on the quantity produced or length of working period needed to complete a task (NSR, 1978). This time model is the only model of those reviewed that structures times using these terms.

![Figure 3](image-url)  
**Figure 3.** Nordic Forest Study Council’s time concept model (NSR, 1978).

**International Union of Forestry Research Organizations**

IUFRO has developed the Forest Work Study Nomenclature (Rickards et al., 1995) as a first step in standardising forest work study terminology and methodology. Building on a number of existing glossaries including BS 3138, Stokes et al. (1989) and NSR, this nomenclature defines general terms pertaining to work study, activities and conditions of work, work measurement terms, and a classification of time concepts in relation to forest work study (Rickards et al., 1995). Björheden and Thompson (1995) outline the problems with two differing systems for classifying observed time in North America and in Scandinavia, indentifying differences in the classification of work elements. The IUFRO nomenclature aims to remove subjective determinations of delay times and to provide clear classification of delays and effective time (Björheden and Thompson, 1995). Like the NSR, this
nomenclature steers clear of terms relating to performance rating and standard time since their relevance and application for forest work study is still disputed and unnecessary for an initial determination of standard terminology (Björheden and Thompson, 1995).

The time model used by IUFRO is based on Björheden’s proposal of basic time concepts (Björheden, 1991) and builds on NSR’s model of time concepts in forestry. This model divides time into non-workplace time and workplace time (Figure 4). Workplace time is further divided into non-work time and work time. Non-work time includes non-work related delays (referred to as disturbance time) and work related delays which includes activities such as meals, rest and waiting for completion of other tasks which this task is dependent on (Rickards et al., 1995). Work time is subdivided into productive work time (i.e. time spent on activities contributing directly to the completion of the task) and supportive work time (i.e. time spent on activities that do not directly contribute to completing the task but are necessary, such as machine setup time) (Rickards et al., 1995).
Compared to NSR’s model, IUFRO does not include travel time (to and from the workplace) in Workplace (total working time) Time. IUFRO does not incorporate short delays into work time (as it is included in gross effective time by NSR). There is no subjective determination of delay times in IUFRO’s model since there is no need to decide if delays are avoidable or not (as in NSR). Like the BSI, IUFRO’s time model does not require these concepts to be any specific amount of time. However, unlike the BSI model, this model does not include allowed rest time as part of work time.

Cooperative Research Centre for Forestry – Australia

Australia’s Cooperative Research Centre for Forestry (CRC) is in the process of developing a ‘Harvesting Machine Evaluation Framework for Australia’ and proposes that this framework be a common framework used for the southern hemisphere (Acuna and Heidersdorf, 2008). The CRC adopts IUFRO’s Forest Work Study Nomenclature and uses it to develop ‘detailed’ and ‘operational’ machine evaluation frameworks. The operational framework is a simplified version of the IUFRO Time Concepts’ structure. In this framework, the standard minimum delay time is to be fifteen minutes (Acuna and Heidersdorf, 2008). Delays greater than fifteen minutes fall under their own category while delays of less than fifteen minutes are considered part of productive work time. Of the glossaries reviewed, the CRC’s new definition for delay time is the only classification of time that is based on the length of a measured time value.

Australia’s CRC proposes two related time models. The ‘detailed’ time model used by the CRC is the same time model outlined by IUFRO (1995). Additionally, CRC proposes an ‘operational’ time model (Figure 5), which is the ‘detailed’ model reduced to include only the most relevant time elements. Within this time model delays less than fifteen minutes fall under productive work time while delays longer than fifteen minutes are their own time element. This model is much more simplistic than the IUFRO or NSR models and does not specify what activities are causing delays and if those activities are avoidable or not.

![Figure 5.](#)

The operational time model as proposed by Australia’s CRC (Acuna and Heidersdorf, 2008).
International Labour Organisation

Kanawaty (1992) briefly defines basic concepts and terms but does not provide a comprehensive glossary like BSI, NSR or IUFRO. However, this general work study text provides a simple time model (Figure 6) and describes how to rate worker performance to determine standard times. This is a general work study text so it is unlike the NSR and IUFRO nomenclatures since there is a strong emphasis on using performance ratings to convert basic time into standard time. The British Standard Scale is used to determine the rating factor to calculate standard time. Also borrowed from the BS 3138 is the machine time model (Figure 1).

![Figure 6. ILO's operational time model (Kanawaty, 1992).](image)

Kanawaty (1992) breaks down “total time” into two general components: basic work content and total ineffective time. The basic work content is the minimum time needed to perform the operation under perfect conditions, including time allotted for rest. Ineffective time is further categorised by time added due to poor product design or materials utilisation, inefficient methods, or human resources (i.e.: absenteeism) (Kanawaty, 1992). This time model focuses more on ineffective time than the basic work content and does not address what tasks or elements make up basic work time. The lack of elaboration on basic work content is likely due to the generalised nature of this model and also the
possibility of using time study to compare alternative work methods. The Kanawaty (1992) publication also provides a standard time model which breaks down the total time in which a job should be completed at some level of standardised performance.

ILO’s model focuses on ineffective time and determining the source of the ineffective time. Work measurement techniques, including time study can be used to identify ineffective time before completing a method study (Kanawaty, 1992). The other time models (IUFRO, CRC, BSI) were not developed with the aim to improve or alter work methods but instead to evaluate a predetermined method.

Other Nomenclatures and Time Models
Another suite of definitions comes from Stokes et al. (1989) in the “Glossary of Terms Used in Timber Harvesting and Forest Engineering”. This glossary includes some common work study terminology, in particular, terms related to machine time and availability. Machine availability is similarly defined by this glossary and the BSI as the time which the machine is scheduled to work and capable of doing work. However, Stokes et al. does not address other terms relating to work study for example in the topics of performance rating, work element classification, or time classification, nor does it provide a time model.

Other common time models include the CPPA and FERIC models used in Canada. CPPA and FERIC address machine work time whereas the other models may be applied to both machine and manual work.

Time Study Protocols
Although work study is a broad concept, the general procedure is similar regardless of the work place to be studied (Mundel, 1978). General protocols for time study have been outlined in work study texts such as the ILO’s Introduction to Work Study (Kanawaty 1992) and Motion and Time Study – Improving Productivity (Mundel and Danner, 1994). These texts outline, step by step, how to develop a study, separate a job into elements, record data, convert the observed time (basic) to standard time, and suggest methods for data analysis. Sample time study data collection sheets, stop-watch clipboard setups and other data collection tips are suggested as well.

Specific to forestry, a number of time study protocols of varying detail have been developed. These protocols include those used by the British Forestry Commission, ILO (Kanawaty, 1992), and CRC. IUFRO has noted that the next step after developing an accepted work study nomenclature is to create standard forest work study methods (Björheden and Thompson, 1995); however no such methods have been developed to date. As a result, several time study protocols exist but there is no international, national or even regional protocol.

An international course on forest work study was held jointly by the FAO/ECE/ILO in 1971 and a number of papers and resources were produced for that event. Amongst the resources published are procedures and techniques for performing method and time studies, compiled into the British Forestry
Commission’s Bulletin No. 47 (Wittering, 1973). The time study protocol is based on paper, wristwatch, and stop-watch technology. The procedure dictates that time data should be collected continuously and recorded in centiminutes. The stop-watch times should be regularly checked with real time in order to isolate errors (Wittering, 1973). Clearly recognisable breakpoints should be used to separate elements and elements with indistinct breakpoints should be grouped together (Wittering, 1973). It is important for manual and machine work to be separated into different elements. Delays and breaks are accounted for under contingency allowances and the time they occupy falls into the Total Work time. This protocol includes a rating procedure based on the British Standard Scale (as defined in BS 3138). The rationale for requiring a rating system is that time studies must allow for changes attributed to both the operator (worker) and the method (Wittering, 1973). In addition to data collection procedures, Wittering (1973) provides guidance on how to perform statistical analysis of work study data.

Apud et al. (1989) provide a simple protocol for carrying out work studies in developing countries using basic time-study equipment and where statistical analyses of data is carried out by hand. This guidebook is heavily based on materials presented at the 1985 ILO/IUFRO workshop held in Tanzania. This protocol divides time elements into three groups; cyclic elements (occur each cycle), other elements (necessary elements that only occur occasionally), rest, meals, and other delays. Two methods of timing; continuous and fly-back, are suggested. A five-step subjective performance rating system, with 100 as the standard is provided. However, this protocol acknowledges that in some countries and regions (i.e. Nordic countries) performance ratings are not used (Apud et al., 1989).

The CRC has developed standard study methods and forms for forest work studies to be conducted with, specific to the operating parameters and conditions in Australia (Brown et al., 2010). The CRC suggests that this protocol could be a standard used throughout the southern hemisphere (Acuna and Heidersdorf, 2008). Guidelines for conducting time studies are outlined by the CRC’s Protocol for Time and Motion Studies where shift level and detailed time studies are described (Acuna, 2010). Detailed time studies are best used to compare alternative harvesting systems and to record small delays (less than ten minutes) (Acuna, 2010). However, detailed time studies are costly and less time effective than shift level studies. Shift level studies occur over a longer period and are more likely to accurately represent the actual working conditions (Acuna, 2010). However, shift level studies do not account for other variables (i.e., piece size, slope, extraction distance) and compound small delays into productive time (Acuna, 2010). A shift level study is therefore best to determine production rates while a detailed time study is best used to show relationships between productivity, cost, and cycle times with piece size and slope (Acuna, 2010).

Once an objective is set, the next step of performing a time study is to break the job into cycle elements (Brown et al., 2010). The Protocol for Time and Motion Studies explains in detail the different elements to be recorded for harvesters, forwarders, feller bunchers, trucks and others (Acuna, 2010). CRC’s Machine Evaluation Toolbox provides sample time study forms customised for each harvesting machine (i.e., harvester, feller buncher, skidder, forwarder, yarker, processor, IFoader, truck, chainsaw, tractor, or chipper) with predetermined time elements in columns.
In the CRC protocol, information other than time records must be obtained, including background information such as slope, terrain roughness, stocking, distance to the nearest road, etc. Also, this procedure dictates that several related independent variables need to be measured in order to create useful models based on the time study data. These variables include species, tree height, piece size, pieces per cycle, extraction distance, etc. The Machine Evaluation Toolbox provides forms for recording relevant information about variables pertaining to the harvesting machine. Also provided are details on steps for field data analysis using regression and cost analysis.

In the Toolbox, various work measurement techniques are explained, including time study, motion study, and instantaneous observations. A table is provided to help users determine which work measurement technique is most applicable to help achieve their objective. For example, if the objective is to identify inefficiencies, then the CRC suggests a detailed time and motion study or instantaneous observation be carried out. Of the protocols reviewed, this one is most recently dated therefore it acknowledges the use of handheld computers or PDA’s as primary data recording tools for time study. The protocol outlines advantages and disadvantages to using paper/stopwatch or handheld computers as primary time study equipment.

Future Developments and Works in Progress

In addition to the CRC’s Toolbox which is still a work in progress, the European Cooperation in the field of Scientific and Technical Research (COST) is currently working on Action FP0902: Development and harmonisation of new operational research and assessment procedures for sustainable forest biomass supply. This COST Action is formally investigating existing terminology relating to forest biomass for energy; work study methodologies and standard biomass measurement approaches; costing assumptions and data analysis methods; and systems analysis and modelling approaches in forest operations (COST, 2009). Amongst other outputs, COST Action FP0902 aims to produce a new forest biomass glossary to replace the outdated IUFRO nomenclature, and also best practices guidelines on work study methodologies, sampling methods, and standard measurements (COST, 2009). All the outcomes of this COST Action will be published online at the Forest Energy Portal (http://www.forestenergy.org) and the scientific articles in the Journal of Forest Energy.

The glossary will be created after compiling existing terminology, standard measurements and units and harmonising the different definitions into a database (COST, 2009). Presently, most definitions included in the database do not relate to work study, but nevertheless the final glossary (to be published in 2012) should be examined for its relevance. The Action’s best practice guidelines is a list of suggested approaches because one standard procedure would not be valid for all situations (COST, 2009). Instead of creating a new protocol, the guidelines will identify if and how two studies are comparable even if they were conducted using different methodologies. The goal is to identify areas where studies can be compared, if equivalences between methods can be found, and where outcomes can be affected by use of different work study and sampling methods (COST, 2009). The expected completion for this project is in 2013.
Conclusion and Summary of Findings

The BSI glossary of work study terms is one of the first comprehensive nomenclatures to have been developed on work measurement. This foundation has led to other published nomenclatures from IUFRO and the ILO (Kanawaty, 1992). IUFRO’s nomenclature is the most relevant glossary of forest work study terms although it has been updated since 2000, which may be an indication of its suitability presently. IUFRO also builds on the framework for time concepts modelling as set forth by NSR but aims to address the NSR model’s shortcomings. The IUFRO nomenclature and time concept model has been adopted by Australia’s CRC for its time study protocol for forestry machines, and in South Africa through Forest Engineering Southern Africa (FESA) as a basis for fundamental understanding of time concepts and the calculation of basic availability and utilisation ratios for harvesting machines.

Although not yet completed, the Toolbox proposed by Australia’s CRC is the most comprehensive and up to date time study protocol currently available. Other protocols are not specific to forestry (Kanawaty, 1992; Mundel and Danner, 1994) or are outdated with respect to recent time study technological advances (Apud et al., 1989 and Wittering, 1973). The CRC protocol is current; makes provisions for both paper and electronic time study equipment; and embraces IUFRO’s nomenclature and time concepts model. However, this protocol has not been completed and implemented so there is a need for addressing how to analyse and compare past and present studies using various other methodologies. In this case, the results of COST Action FP0902 should be reviewed as the proposed best practices guidelines should give guidance on how existing studies can be compared.

This review concludes that no formally accepted work study protocols or updated nomenclatures exist. However, the development of a completely new protocol and glossary seems unnecessary because there are enough existing protocols and nomenclatures that can be adopted or have value added. South Africa can adopt existing protocols and glossaries to be used as its standard. Furthermore, cooperation with Australia’s CRC, in the form of funding and other resources could result in the creation of a standard for the southern hemisphere. As far as Cost Action FP0902 involvement is concerned; South Africa, in the form of Stellenbosch University, has a fixed presence in two of the four working groups and is currently hosting a number of “Short Term Scientific Missions” of the Cost Action in South Africa. This interaction will assist in the dissemination of information to the local industry and to further greater understanding and application of work study principles in the Industry.
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