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DEVELOPMENT AND APPLICATION OF REALISTIC AND CONSISTENT MANUFACTURING DATA AS A BASIS FOR SIMULATIONS

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ABSTRACT

To do simulation studies without the appropriate manufacturing data is like using a map without enough details. You may or may not be able to find the right location. Many simulation engineers are missing the map that is detailed enough to give them the correct locations for the work elements. They are missing an important tool called work measurement to generate appropriate manufacturing data. With such a tool, they can do their simulation studies with accuracy and confidence. Work measurement is a fundamental industrial engineering discipline primarily used to improve productivity and the quality of management decisions. The paper will discuss why and how work measurement should be used. Several examples of applications in a simulation environment will be presented.

It's a matter of "time," a critical element in a simulation study.

1 INTRODUCTION

The purpose of this paper is to introduce a multi-functional, industrial engineering tool to help simulation engineers improve the results of their work. The problem that the simulation engineer often has is to accurately quantify the workload at the work stations that make up the simulation model. The problem becomes even more apparent when work is moved between the work stations and when improvements or changes are made to the work conditions. The tool that will solve these problems is called *work measurement* and comes in many different forms and shapes. Therefore, it becomes very important for simulation engineers to understand both why they should use this tool and why some work measurement tools are better than others. Work measurement is being used primarily to establish so-called *time standards* for operations performed by people. These operations are therefore characterized as manual operations. The quality of time standards depends on how they are being developed and which work measurement tool has been used to establish them.

In order to produce quality simulation studies, proper manufacturing data or time standards need to be present. Often the problem is that such data is not available to the simulation engineer. Therefore, in order to have some numbers to use for the workload, he or she resorts to guesses or estimates. To properly fit two parts together they have to be made to very accurate measurements and guessing or estimating the dimensions and tolerances would not be acceptable. The same is true for simulations. Why should simulation studies not be built on accurate manufacturing data? It must be frustrating for the simulation engineer who does not have access to reliable manufacturing data. Therefore, in this presentation, I will demonstrate a work measurement tool that will support the simulation engineer in his/her efforts to generate high-quality simulation studies based on accurate time standards for workload determination.

We will begin by defining what we mean by *manufacturing data* and ask ourselves the question: Why do we need time standards at all? We will discuss the applications and the benefits of time standards and review the differences between engineered and non-engineered time standards and look at the most common work measurement techniques. The second part will focus on how to measure work and calculate time standards. For that purpose, we will take a closer look at the MOST® System and show examples of how work is measured and time standards calculated using that system. We will then continue discussing how time standards can be used in simulation-type situations such as line balancing and simulating the effects of changes in work conditions and products. Actual application examples will illustrate how companies in several different industries are using this tool. We will then summarize the presentation by reviewing the benefits of the work measurement tool for simulation engineers.

2 MANUFACTURING DATA

Manufacturing data can be defined as a complete description or documentation of work conditions including workplace design, equipment, tools, layouts, methods, standard practices, and time standards. Process data such as feeds and speeds, arc times and other process-controlled data are also part of the manufacturing data. In order to fully understand a manufacturing process, it is necessary to have reliable manufacturing data documentation available. And in order to establish realistic and consistent time standards, they must be backed up by actual and well-documented work conditions.

2.1 Engineered vs. Non-engineered Standards

The fastest and least expensive way to set a time standard is to guess. Anyone can do that without training. "Guesstimates" as they are sometimes called do not at all meet the requirements on the accuracy and consistency required for proper simulations, and no backup documentation whatsoever is provided. Unfortunately, this method is being used too often. A "guesstimate" is an extreme example of an *non-engineered standard*. Other methods being used to establish non-engineered standards are "qualified" estimates, historical data, self-reporting, work sampling, stopwatch time studies, and benchmark comparisons. The quality of time standards produced by these methods is usually not acceptable. Since documentation of work conditions is non-existent or inadequate to back up time standards established by these systems, they can all be classified as non-engineered standards. The time values are normally being determined through a mental process (estimating, self-reporting) or by observation (work sampling, stopwatch time studies).

To establish an *engineered standard*, a so-called pre-determined motion time system is being used. Prior to calculating a time standard, work conditions within the concept of manufacturing data as defined above will be documented based either on actual methods or planned (improved) methods. Engineered standards are like an engineered drawing of a part or product. All necessary shapes, dimensions, and other data are specified in detail. Therefore, an engineered time standard is the result of complete specification of the work conditions. As we shall see later, a computer system being used for work measurement requires only the input of workplace data and methods and subsequently the time standards are being produced automatically. Therefore, engineered standards are more accurate and have a high degree of integrity, because the time values match or correspond to the actual work conditions. And, if these work conditions change, the time standards will change accordingly.

3 WHY TIME STANDARDS?

Based on the discussion above, an engineered time standard is defined as the time it should take to preform an activity or do a job based on documented work conditions and established methods. By following this definition, our time standards will be realistic and consistent. Having access to high-quality standards, the simulation engineer will be able to do a much better job with his or her simulation studies.

High-quality engineered time standards are being applied for many reasons and in many areas such as: staffing and scheduling, crew sizing, line balancing, process planning, cost estimating, budgeting, equipment justification, make-or-buy decisions, performance reporting, wage plans, facility layout simulation, work instruction, CIM and MRP-II support, but above all engineered time standards can and should be used as a vital management tool, a tool that will provide for timely and accurate management decisions.

There are several important reasons why we want to measure work: to satisfy the desire and need to know and predict with confidence; to satisfy the basic human wish to know what is expected from a person; to control staffing cost and performance; to provide a basis for incentive plans, estimates and budgets; to increase the company's competitiveness; to support simulation studies. Above all, work measurement is a fundamental tool to improve productivity. By using a pre-determined motion time system for work measurement, a thorough and often detailed work analysis has to be made, and in the process, the industrial engineer will create more efficient workplaces and methods resulting in an overall productivity improvement.

Therefore, the main reason for performing work measurement is to improve productivity and to produce reliable time standards that will become very useful in a number of areas as we have seen above.

There are a number of work measurement techniques available in the category of *pre-determined motion time systems*. As the name indicates, all time values are pre-determined and available on datacards or in a computer software program. These time values are "normal" times based on an average skilled and trained worker performing a task at an average performance rate.

These systems can be divided into three categories: basic *motion-based* systems such as Methods Time Measurement (MTM), Work Factor, and Modapts. There is a second level of conventional *element-based* systems such as MTM-2, MTM-3, USD, etc. A more recent development has produced an *activity-based* system called MOST (Maynard Operation Sequence Technique). The motion-based systems are often very detailed and time-consuming to use. While the element-based systems are faster, they still require a substantial amount of time to apply. The activity-based system (MOST) takes a more logical and practical approach to the measurement of work and is, therefore, more user friendly and faster to apply.

Before we look at an example of how to measure work with MOST, we need to understand that there are basically two ways to calculate a time standard. The first method utilizes the work measurement technique for direct measurement of an operation which is usually defined as a continuous activity performed by an operator at the work station at one time to join parts (assembly, welding) or to modify parts (machining, fabrication), or to make parts (casting, molding). This method is mostly used for measuring short, unique operations such as sub-assemblies. A second more common way of calculating a standard is by applying the work measurement technique to develop larger building blocks or *standard data units*. These standard data units will then be combined in different ways to calculate a time standard for an operation. Standard data units are sometimes called sub-operations because each one of them represents a portion of an operation. This approach becomes a fast and economical way to develop and maintain accurate time standards.

4 HOW TO MEASURE WORK AND CALCULATE STANDARDS

As stated above, the most common method of calculating a standard is to use a list of sub-operations for a specific workplace or workstation called a "worksheet." This worksheet is like a restaurant menu. Instead of combining various courses for a meal, one chooses the activities that have to be performed to complete an operation. Each such activity consists of a work measurement analysis with a time value attached to it. Therefore, after selecting the appropriate activities, the computer can automatically calculate a final time standard including allowances (personal time, rest factor, unavoidable delays) and produce a method instruction for the operator.

This calculation process can be further automated by using an expert system. Rule-sets and decision models will be built into a computer system that can make automatic selections of activities and thereafter calculate the time standard. This is a particularly attractive approach when large numbers of time standards have to be calculated.

A simple example will illustrate how we can measure the work involved in a sub-operation or activity on the worksheet. We will use the BasicMOST work measurement technique for this illustration. Based on the definition above of an engineered time standard, we first need to specify the work conditions. Therefore, we will make a simple sketch of the workplace indicating the locations of and number of steps needed between the workplaces and possible body motions being required. Secondly, we need to know which method is being used to perform the activity, which in this case is to move the work piece from the pallet to the workbench. The third step is the analysis itself, and we will use one of three so-called *sequence models* that make up the BasicMOST work measurement technique. The sequence model represented by A B G A B P A includes all the parameters or variables required to perform a "general move" activity meaning that we move an object freely through the air from one location to another. The other sequence models are "controlled move" and "tool use."

In order to do the analysis, statistically determined and fixed index values will be assigned to each of the parameters in the sequence model. Therefore, in this case, walking three steps to the pallet, the first A in the sequence model is *action distance*, and a "6" will be assigned. The second parameter, *body motion*, is a bend (and arise). That is a B_6. The G for *gain control* is a simple grasp of a small object, therefore a G_1. The second A is an *action distance* back to the workbench which is another A_6. At the workbench, no *body motion* is needed, so therefore, the second B will have a "0" index value. The P for *placement* is a simple placement, or in this case, a P_1, and the last A is the *action distance* returning to the workplace, which in this case will be a "0" since the operator is already there. Therefore, the completed sequence model will read

$$A_6\ B_6\ G_1\ A_6\ B_0\ P_1\ A_0$$

By adding the assigned index values together, we will get the sum of 20. After multiplying by 10, one gets 200 TMUs (Time Measurement Units) which corresponds to approximately 7 seconds. (One TMU equals 1/100,000 of an hour.) Through this simple illustration, one can see how easy it is to measure the work by just applying index values directly from memory and calculate the time by adding these index values together. The normal time of approximately 7 seconds is based on the actual work conditions, and becomes therefore, a realistic and reliable time standard of about 8 seconds after adding the allowance factor (usually around 15%).

If the computer program is being used to input the work area data and method, the computer will automatically fill out the index values and calculate the time from the sequence model.

As mentioned above, the purpose of work measurement is to improve productivity and in this simple example, we can conclude that the high index values for A_6, B_6 and A_6 will contribute more to the total time standard than the other index values will. Therefore, by changing the work conditions, in this case the workplace layout, we can reduce the index values and come up with a more efficient method and time standard.

By moving the pallet to an elevated position next to the workbench, the operator needs to take only one step to the pallet and use no bend. The sequence model analysis will be as follows:

$$A_3\ B_0\ G_1\ A_3\ B_0\ P_1 A_0$$

The time value will be reduced to 80 TMUs or roughly 3 seconds. The purpose of this example is primarily not to show that we can improve productivity by over 100%, but to show how easy it is to determine time standards by using the MOST technique and applying it to for different work conditions. And the index values will indicate to the engineer where improvements should be made.

5 PRACTICAL EXAMPLES OF USING TIME STANDARDS

As indicated above, reliable engineered time standards are very useful in many areas including simulation. Therefore, we will look at actual applications of a Windows-based computer system that does the work measurement based on MOST, calculates time standards, and maintains those time standards. This computer system is often being interfaced or integrated with other computer systems in order to electronically transfer data between them. We will review a warehouse application where standards were used as input to a simulation program. We will look at a truck manufacturing company where the computer system is being used to determine the balance and station assignments for assembly lines. We will also look at a utility using the system for simulating schedules and determining crew sizes. We will refer to a tire manufacturer that is using the time standard as input for developing production cells. Finally, we will take a look at how the computer system can be used to simulate the effect of changes in work area conditions (actual or "what if") on productivity improvements.

6 SUMMARY

The purpose of this presentation was to introduce a tool based on the latest computer technologies and work measurement techniques to be used by the simulation engineer to improve the quality of his/her simulation studies. By utilizing realistic and consistent engineered time standards, the results of the simulation studies will become more reliable. For the simulation engineer to have access to high quality time standards should be a step forward in the process of improving the simulation results. The benefits of work measurement to a company and the simulation engineer are numerous as we have discussed in this paper.

Work measurement is a tool that usually is being implemented by industrial engineers but can very well be used by others including simulation engineers. Over 20,000 people have been trained to use the MOST tool in many countries and in many industries. For the simulation engineer, it's a matter of utilizing a proven technique to build a quality simulation product. And please remember that any simulation model is only as good as the input data used.

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