TIME DATA MANAGEMENT

- A handbook

Peter Almström

Foreword

This handbook is about Time Data Management (TDM) and it can be read from cover to cover to get an overview. Alternatively, you can look up what you want to read about via the Table of contents to the right. The primary audience is technicians and managers at manufacturing companies who are beginners in the field or want to start from scratch and build a solid foundation of time data from the ground up. Many topics in the handbook are only touched upon briefly, but there are references to more in-depth literature or websites.

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Pleasant reading!

/Peter Almström, author and project leader

All individuals who contributed to the handbook are presented on the last page.

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1. Why Time Data Management?

1.1 Advantages of having good time standards

Many companies suffer from poor quality time standards. A time standard is time data that is stored in planning systems or databases and is used for planning production, calculating costs, and making various strategic decisions such as make-or-buy decisions. Time Data Management is the determination, use and administration of these time standards (Kuhlang et al., 2014). The time standards stored in data systems tend to not match the actual times on the factory floor. Many managers think that the time difference is small and constant, when the difference is substantial and very variable. There are several reasons for the current situation, such as times being set incorrectly from the beginning or times not being updated when changes occur in production. For instance, investing in a robot can significantly reduce the cycle time, but the planning department that handles the time standards in the planning system has not received the updated time change. It’s common for companies to not at all adjust a time standard once it has been stored in the system (Almström and Winroth, 2010). There can also be different times for the same activity stored in various systems for different purposes. The most important reason for this situation is the lack of insight by corporate management into the importance of having accurate and updated time standards.

With digitalization, many companies have started to realize that their time standards are not good enough for making important decisions; this applies to both operational and strategic

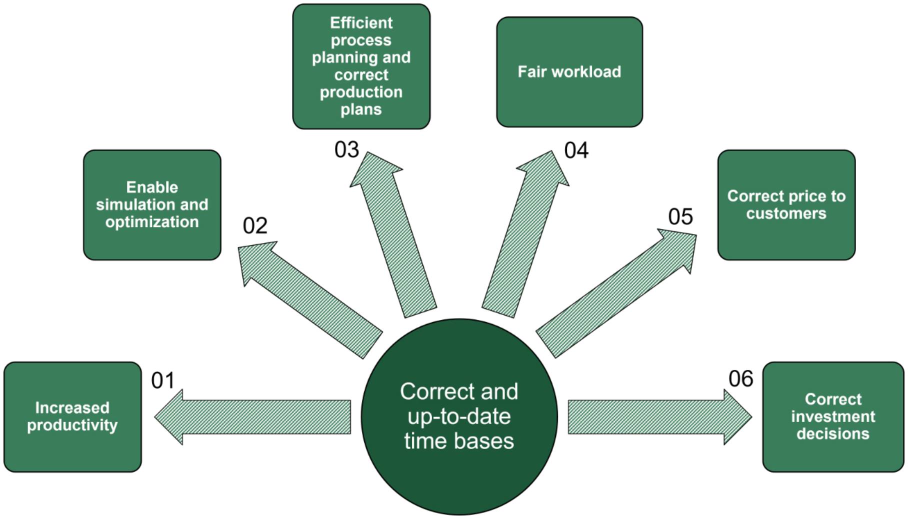


Figure 1. Accurate and updated time standards lead to increased productivity, enable simulation and optimization, result in correct planning, provide fair workload, the correct price to the customer, and the correct investment decisions.

decisions. Time standards, for example, are used as the basis for preparing quotes and investment calculations. But the times that are in the data systems often do not match the actual time it takes. This leads to optimization algorithms not being usable, productivity being low because planning must account for the times not matching, and it being difficult to know if the workload is fair, both between two operators and towards the company (Figure 1).

It's important to understand that good time standards require some effort to design and maintain. There is a trade-off between the time invested and the benefits, which we will return to.

1.2 Time standards and Lean

Fifty years ago, when piece-rate pay was the common form of wage system in the manufacturing industry, companies had high-quality time standards. Without accurate time standards, workers would not receive the correct payment. When most switched to fixed monthly salaries in the 1970s and 1980s, much of the motivation to update and maintain the quality of the time standards disappeared (Luthman et al., 1990). For a while, many companies could continue to use the old time standards, but with new products and improved processes, the quality of the time standards deteriorated over time. With new organizational forms, it also became "ugly" to measure times. Companies wanted to create trust and not "chase" workers as they had done before with piece rate wages. The companies that have maintained the quality of time standards are mainly those with assembly lines. Good time standards are a necessity to balance a line. In the rest of the manufacturing industry, the competence in time studies has literally retired.

Around the turn of the millennium, there was a widespread attitude that production should not be conducted in high-cost countries like Sweden. A significant wave of outsourcing swept through the industry. Especially the assembly of products with a large manual labour content disappeared to low-wage countries. However, sense prevailed, and many realized that there was much that could be improved in the existing factories. The inspiration came from Japan, and Lean production emerged as the solution to produce in high-cost countries. The focus was on continuous improvements, which is logical when there is great potential for improvement in existing work. Companies began again with work studies to standardize and identify wastes. Unfortunately, the popular Lean literature only mentions time studies with a stopwatch as the method for determining times (see, for example, Liker, 2021). Toyota surely uses its own time block system to set correct times for work in the design phase, but this is not mentioned in the books, and therefore many believe that time study with a stopwatch is a sufficient method. Later in the handbook, we will explain why this is not sufficient and how a time block system can help every company to get it right from the start and then apply continuous improvements (Figure 2).

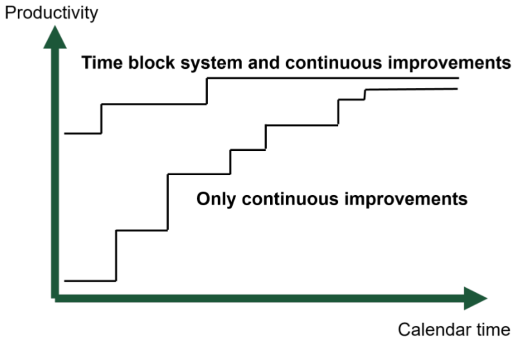


Figure 2. Time block systems in combination with continuous improvements lead to higher productivity in a shorter time than continuous improvements alone.

2. Time and productivity

2.1 Defining different times

There are many types of time that an industrial company needs to master. There are planned times, actual times, cycle times, setup times, lead times, throughput times, allowance time, and so on. It might sound obvious, but the fact is that few companies have a proper standard for how times are defined and moreover how to use that standard. What a time is called in the software the company uses to administer and utilize the time standards, for example in the ERP system (Enterprise Resource Planning), often becomes a de facto standard. The lack of a suitable standard means that people talk past each other or that calculations of metrics are wrong and not comparable within the same company.

Each company should establish an internal standard for time definitions that suits its own operations and that is based on the vocabulary used in the company. An example of what the standard could look like is shown in Table 1. A Swedish standard exists for different times and related concepts in TNC 49 with translations to

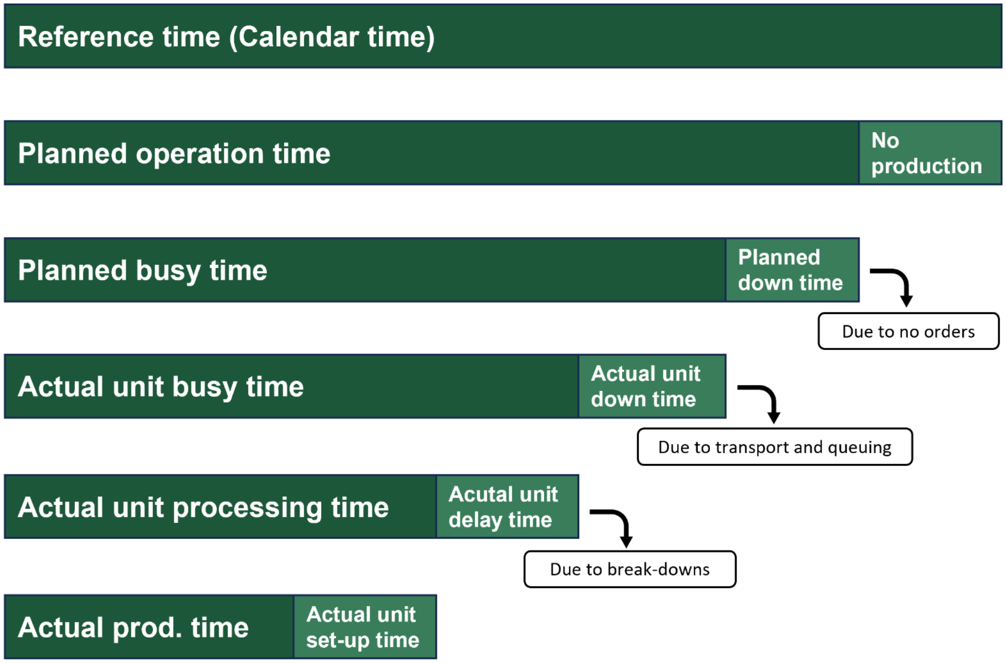


Figure 3. Each company should establish an internal standard for time definitions. The time diagram is an example of times standardized in ISO 22400 (ISO, 2014).

Table 1. Definition of cycle time and setup time.

Name	Unit	Definition
Cycle time	Seconds	Time from the start of assembly of one product to the start of assembly for the next product.
Re-setting time	Minutes	Time from the last component in batch N to the start of the first component in batch N+1.

English and German (TNC, 1971). There is also a much newer international standard; ISO 22400 (ISO, 2014), which includes definitions of times for the manufacturing industry (Figure 3).

2.2 What is value-adding time?

With a focus on what creates value for the customer and reducing waste, it naturally leads to discussions about value-adding time. It may sound like a simple metric to define, but it is not. Even if an activity adds value for the customer, it does not have to be designed or performed efficiently. For example, a robot that loads and unloads workpieces into and out of a machine is probably more efficient than having an operator do it, if the volume is high and the variation is small. It is also not as simple as saying that the value-adding time should be as large a proportion of available time as possible. There are plenty of activities that need to be performed so that the value-adding activities can be carried out. For instance, material handling does not add value to the customer, but it is necessary. Should then all the time that logistics personnel spend on the job be considered as waste? An analysis of a task that results in a distribution of value-adding, supporting, and non-value-adding time (Figure 4) works for some activities but not at all for others. A company that takes continuous improvements seriously therefore needs to first define *all* activities carefully, then question how they are performed and how long they take.

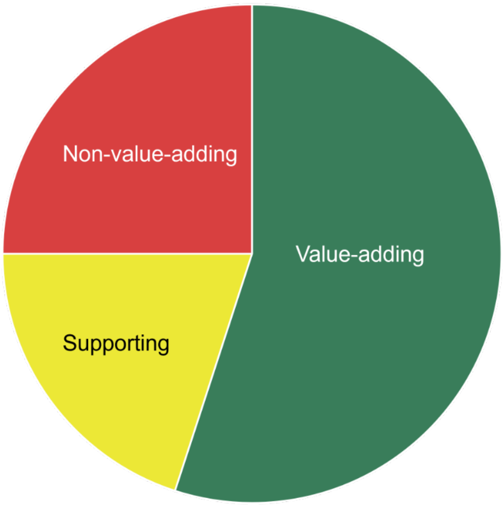


Figure 4. An analysis of a task may result in a distribution of value-adding, supporting, and non-value-adding time.

2.3 Working time, setup time and allowance time

Traditionally, the term "allowances" has been used to indicate the time spent on activities that are neither value-adding time (working time) nor setup time (Figure 5). Allowances can be divided into time spent on necessary but not value-adding activities, such as material handling, meetings, and cleaning, and all other undesirable but sometimes necessary activities. Setup work and other activities performed per batch are usually not counted as allowances, but different types of allowances can be part of the setup time. There are many ways to break down time into various categories. The important point is that each company must come up with a relevant internal standard for the company's needs.

If the goal of time setting is to produce a time that can be used for planning, cost, or capacity calculations, one must also measure or assess allowances as well as setup time. Often allowances are treated as a lump sum in planning systems, for example by multiplying all operation times by a constant factor. This may make the planning add up over a longer time interval, but it's likely that the variation between different machines and products is so great that the timing becomes meaningless on a daily basis. Setup times are treated in the same way. Setup time for machine tools is a good example. Often it has been assumed in the planning that the setup time is the same for all machines and products. This assumption is, of course, incorrect. Even in an ideal case, if one ignores all variations such as disturbances, the setup time can vary within a machine depending on which product one is switching to and from. The setup time from product A to B does not have to be the same as the setup from B to A in the same machine. In one case, a fixture may need to be calibrated, and in the other case, one may only need to remove the fixture. Industrial companies need to demand from suppliers of various data systems that use time standards, to include more detailed data fields with times divided into many more categories than today.

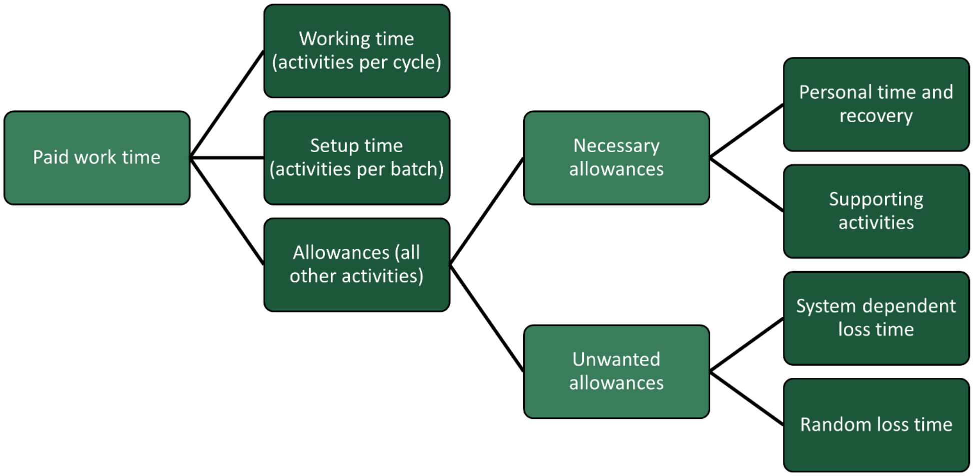


Figure 5. A division of working time into working time, setup time, and allowances. There are many different variants of such a division.

Allowances are necessary when a person performs a task. We can never expect a person to be able to work 100% of the paid working time. Therefore, time must be allotted for personal time and recovery. This time is typically agreed to be 9% of the working time, or 5 minutes per hour (Kanawaty, 1992). Often these 5 minutes per hour are combined into a longer paid break in the morning and afternoon. Additional allowances may be required depending on the nature of the work and physical work environment factors such as high or low temperature.

2.4 Efficiency and productivity

Effectiveness is to satisfy customers' needs while minimizing costs or other resource consumption. Efficiency is producing in the right way and using available resources in the best possible manner. Both perspectives can be used to define metrics, and both are related to productivity. Productivity is defined as output divided by input, where output and input can be many different things depending on the purpose. Productivity can be measured at different levels, from national productivity (gross national product divided by the number of hours worked in the country) to productivity for an individual activity (number of products per worked hour). High productivity leads to high internal efficiency and high productivity with the right quality leads to high effectiveness.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Productivity and efficiency are also closely related to capacity. Capacity can be measured in two ways, either as input capacity or as output capacity. Input capacity is the capacity one has invested in and can, for example, be when a subcontractor has invested in a milling machine with a certain capacity in terms of the number of machining hours per year. Output capacity is the result of the production measured in the number of products per unit of time. An example of output capacity is the number of chairs produced per hour. Thus, output capacity can have the same definition and measurement as productivity. Productivity at the activity level can then be measured as the number of products produced per hour.

Another measure that is also gauged by stating the number of products produced per hour is the customer demand rate. If the demand rate is inverted, that is, 1 divided by the demand rate, we can find out the takt time by calculating seconds per product. Takt time is the same as the maximum cycle time at the bottleneck station in a flow. The inverse of cycle time is thus the same as productivity at the activity level.

$$\text{Productivity (at activity level)} = \frac{1}{\text{Cycle time for the activity}}$$

2.5 The productivity factors: Method, performance, and utilization

To understand what determines how long an activity takes, it is important to understand the productivity factors: Method, Performance, and Utilization (MPU). These affect the productivity at the activity level and the cycle time for the activity. The Method factor (M) indicates how the work is intended to be performed, what movements need to be made, how the workplace is arranged, and what aids, tools, or machines should be used. The Performance factor (P) is determined by the speed at which the work is performed in relation to a speed or performance standard. The Utilization rate (U) is determined by what proportion of the working time that is used for value-adding or supporting activities and how much time needs to be spent on losses such as waiting and disturbance handling.

The Method factor provides an ideal or standard time that can be used as a target, while the Performance factor and the Utilization factor are determined by losses and disturbances that should be reduced through continuous improvements. The goal is to always get as close to the ideal time as possible. Often, P and U losses increase directly after an M improvement because the operators need to learn the new method and because new disturbances occur (Figure 6). To explain in more detail what affects performance and utilization rate, we can divide them into subfactors (Table 2). The quality outcome also affects the productivity at the activity level, but for example, scrap rate due to manual work usually have a very small impact compared to M, P, and U.

Table 2. Subfactors to Method, Performance, and Utilization and what affects them.

Factor	Sub-factor	Is affected by
Method		How the work is designed to be performed without losses.
Performance	Person based	Physical ability and the motivation of the person.
	Skill based	The individual’s skill through training.
Utilization	Personal needs	The person's need for a micro-break or rest during working hours.
	System dependent	The design of the system that results in e.g. balance losses.
	Disturbance affected	Losses due to random disturbances.

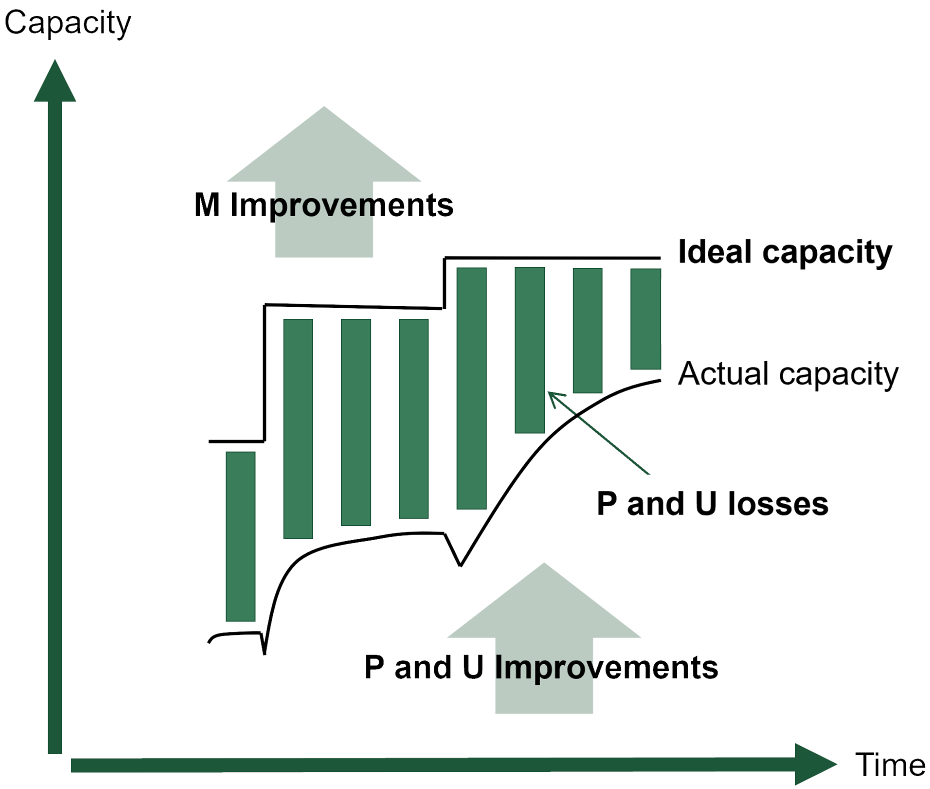


Figure 6: The method determines the ideal capacity, while the performance and utilization factors reduce the actual capacity.

3. Activities

3.1 To define activities

Not only do the names for times need to be standardized, but the activities performed in production also need to have standardized names. Each company needs to develop its own standard for it to be relevant to the operations. When reviewing the activities, it may be appropriate to analyse and question the activity (Table 3). This can lead to insights about activities that mean the same thing, that are performed unnecessarily, or at the wrong occasion.

A definition of activities should also include a hierarchy, see an example of such in Figure 7. The top level is termed Operation. In the manufacturing industry, the concept of an operation is established to denote a series of activities and support activities that are carried out with one machine or at one station. For

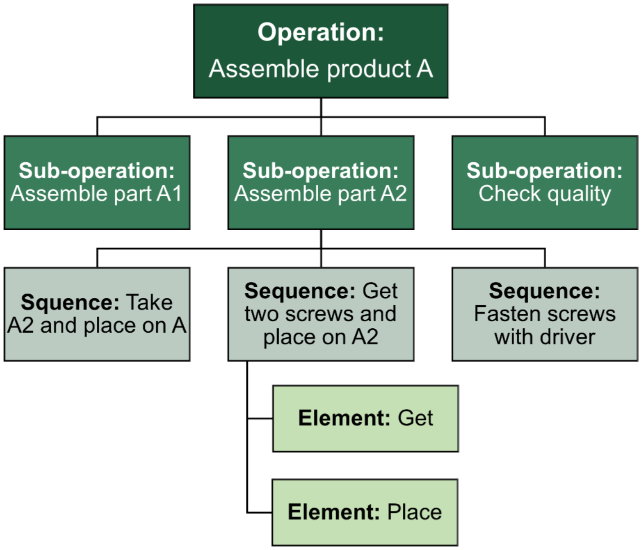


Figure 7. Example of a hierarchy of activities.

Table 3. Systematic analysis of an activity.

Question	Sub-questions (Ask: Why?)
What is done?	Why is it necessary to perform the activity? Can it be eliminated?
Where is the activity performed?	Why is the activity performed here? Can it be better performed somewhere else?
When is the activity performed?	Why is the activity performed at that particular time? Can it be performed at a different time or in a different sequence?
Who performs the activity?	Why does that person or function perform the activity? Is there someone better suited?
How is the activity performed?	Why is the activity performed in that manner? Is there a better method?

example, the Assembly Operation that denotes the assembly of all components for a product at one station. Operations can be broken down into many hierarchical levels if the operations are large and complex. In Figure 7, we propose Sub-operations which in turn are broken down into Sequences. The lowest level in the activity hierarchy is usually called Element; these are the smallest constituents or atoms in the TDM system. Different companies have needs for different minimum sizes (in terms of time consumption) for the elements. However, taking a step is typically an activity that most benefit from having as a separate element, since each step is such an obvious waste.

3.2 Operation step

With the aim of creating an efficient TDM system, principles are needed for how activities should be generalized and grouped at the different levels in the activity hierarchy. Dividing and grouping activities in a systematic way is called operation step division. All activities in the hierarchy can be an operation step, and combinations of activities on the same hierarchical level or on different levels can also form operation steps.

An important principle is not to mix activities that are performed with different frequencies in the same operation step. Activities should be differentiated based on how often they are performed:

- Every cycle (for example, assembly work)
- Every batch (for example, setup work)
- Every new product (for example, preparation work)
- According to certain regularity (for example, preventive maintenance)
- Randomly (for example, disturbance handling).

When designing operation steps, it is natural to set the boundary for the operation step when the work changes character, either because the activities are done at a different frequency or because there are other variables that control the time consumption for the activity. If the operation steps are included in activities in a flow that should be balanced, it is natural to define operation steps based on the smallest balanceable sequence, for example, it is not logical for an assembler to fetch a tool without also using it. An important distinction is between activities that are performed regardless of the layout of the station where the activity is performed and those that depend on the layout. If this distinction is made, many operation steps can be common and used in several different factories in different places in the world regardless of the specific layout at each location. Furthermore, there are four requirements that each operation step should meet. The operation step should be:

1. Universally usable, by generalizing names and making them useful for more than, for example, one component.
2. Repeatable, so that the operation step can be multiplied by the number of times it is performed.
3. Combinable, by determining the boundaries between operation steps in a smart way.
4. Descriptive, so that the operation step name can be used in a work instruction.

Meeting the descriptive criterion can be difficult if the operation step is large (covers a long time), as it will probably require more detailed work instructions for, for example, an assembler to perform the work. Different companies have different needs for detailing and thus the size of the operation steps, and there is always a trade-off against the effort involved.

3.3 Types of operation steps

To make operation steps universally usable, activities need to be generalized. This generalization is probably not apparent for any company. Therefore, when designing operation steps, it is natural to start with Specific Operation Steps (SOS) for a component in an operation. As more SOS are formulated, commonalities will be recognized, and from there, abstraction can be made, leading to the design of General Operation Steps (GOS). For example, if a company assembles several smaller components onto a larger base structure and all the components are fastened with a number of screws, one may realize that the movements performed by the assembler are very similar regardless of which small component is mounted. In the example, the time will mostly depend on the number of screws, and a GOS can be formulated as "Assemble small component with N number of screws". If the time difference cannot be accepted because it creates too much error in the sum of all operation steps, then the general operation step must be broken down into further detail.

According to the earlier discussion about different types of activities, GOS can be divided into several types that should be stored in different activity hierarchies in different libraries or databases. For activities performed every cycle, it is probably important for companies in larger groups to create GOS that are layout-independent (LI-GOS) and distinguish them from layout-specific GOS (LS-GOS). The layout-independent GOS will be owned by the corporate common production development or preparation department, while LS-GOS will be owned by the respective factory. Ownership means that the organization is responsible for the timing and updating, but the names of LS-GOS can be common to the corporation. For example, "Pick component from material facade" is a common name, but the time for the operation step varies depending on the layout.

Activities performed with a frequency other than per cycle, such as per batch or regularly, should be placed in separate hierarchies to avoid mixing or confusing them. Especially, setup work is important to standardize and set time so that it can be improved. Activities performed on a new product may be performed so infrequently that there is no need to standardize and determine time for them. Disturbance handling activities are standardized in many high-performing companies, but time-setting may not be necessary.

4. Time determination

4.1 Time determination and TDM maturity

Both planned times and actual times need to be determined efficiently, meaning with a reasonable amount of work and the right quality. For planned times, which can also be called standard time or ideal time, the time for each operation step is determined before the work exists in reality. Therefore, it is not possible to measure planned times; instead, the time must be determined in another way. Actual times or outcome times should be measured with a method suitable for the purpose, and there are several to choose from. To both determine a planned time and to measure an actual time, a clear definition of the activity that takes time and the type of time it involves is needed, as described in section *2.1 Defining different times*. To maintain the quality of time standards over time, continuous improvements are needed. Changes constantly occur in the form of activities being added and removed, activities being improved through method changes, or by reducing P and U losses. To capture these changes, the actual time must be constantly compared to the planned time, and the difference between them analyzed. If the difference is due to random deviations, no action may be needed, but if it is due to a change, the time standards need to be updated (Figure 8). Without these constant analyses and improvements, the company will not be able to realize all the benefits that come with having accurate time standards.

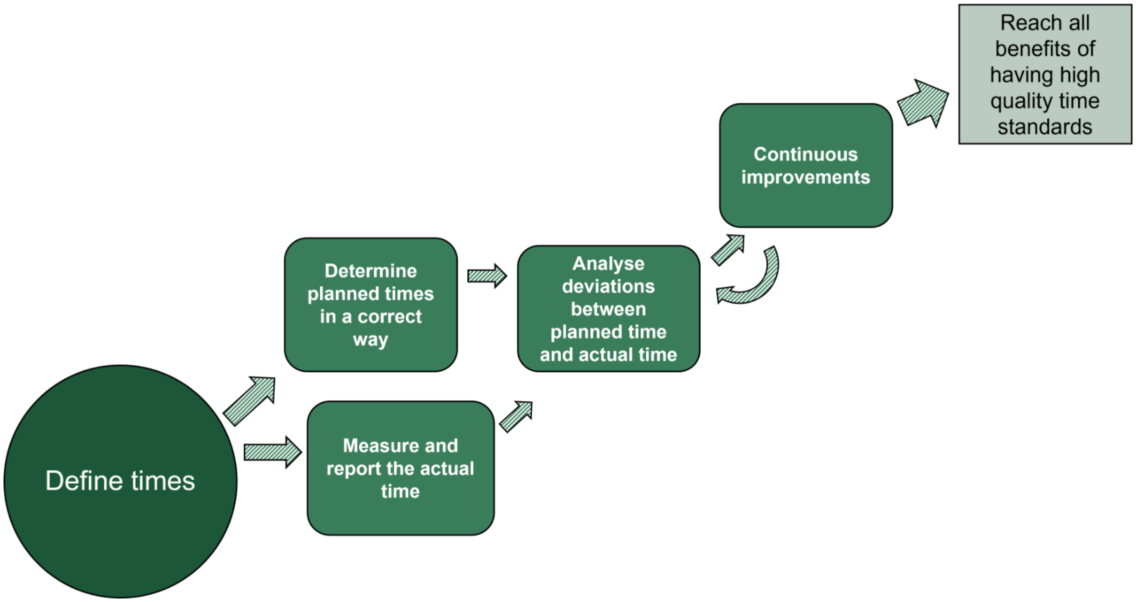


Figure 8. Maturity model for time data

4.2 Time determination methods

There are many different methods for determining planned times and measuring actual times. Actual times are times for activities that can be measured as they are performed. Planned times are set or designed for activities that have not yet been carried out and thus cannot be measured. The right method must be chosen for the purpose of the analysis, and both planned and actual times must be determined to achieve the benefits of high-quality time standards. Figure 9 summarizes the most common time determination methods.

Estimation is unfortunately a common method to "measure" the time for an activity. It usually involves the manager asking the employee how long an activity typically takes. The answer will depend on the operator's attitude and relationship to the manager and the company. The estimation can also be done in the form of the operator reporting an outcome time "on a hunch." The precision can be very poor.

Self-measurement can result in as poor a quality of time standards as estimation. It is often easy to manipulate the measurement or the data that self-measurement results in. Self-measurement can be done in the form of a time study with a stopwatch and a work sampling study using apps designed for the purpose on a mobile phone.

Time study with a stopwatch, video time study, work sampling study, and measurement with sensors are covered in separate sections below. Comparative and estimation are unfortunately common methods for determining time for planned activities. Typically, this is based on an

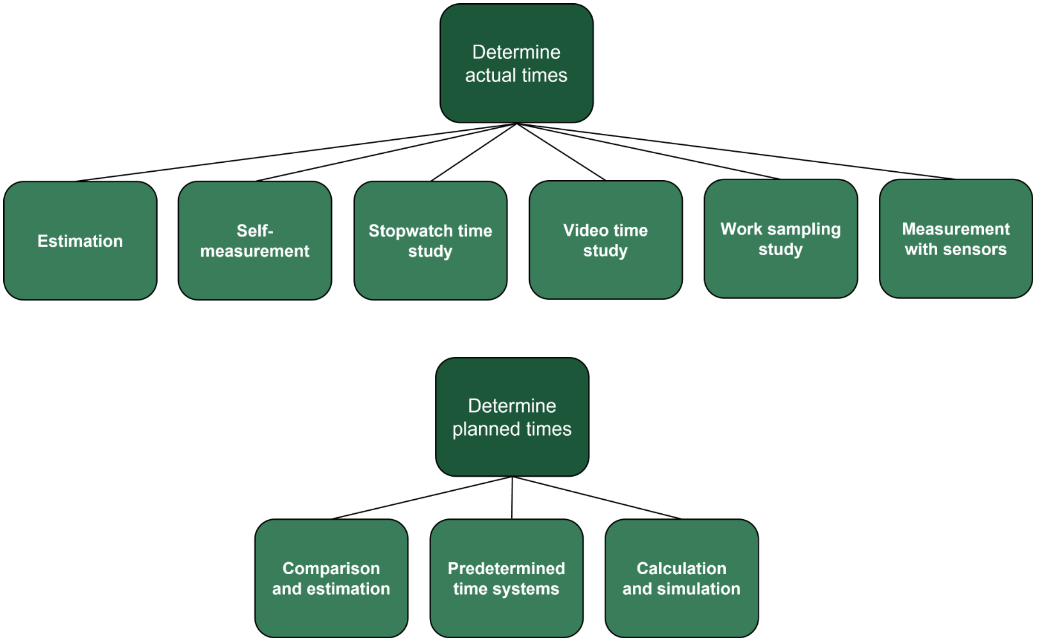


Figure 9. Common time determination methods for actual and planned times.

existing similar activity that has a time standard stored in the planning system, and it is assumed that the new activity will take approximately the same amount of time. Better alternatives include using predetermined time systems or calculation and simulation, which are described in their own sections below.

4.3 Select the correct determination method

There isn't a single time determination method that is best for all purposes. The various methods require different levels of effort to use, in terms of training for the analyst or investment in new technology. It's always a trade-off between the time or cost to perform the analysis and the expected outcome. The purpose will guide the choice of method. In Table 4, the four classic work study methods are compared. Measurement with sensors and 'calculation and simulation' differ radically from these as those methods depend on technical equipment and software to perform the analysis. The classic work study methods are performed by an observer who also analyses the result, or an analyst who conducts the study (in the case of Predetermined time system). Measuring allowance time is a specific purpose for work sampling study.

Table 4. Comparison of four classic work study methods: Stopwatch time study, Video time study, Work sampling study, and Predetermined time system.

Method	Purpose	Pros	Cons
Time study with stopwatch	Measure time for work sequences in running production. Measure machine time.	Fast and easy to perform. Easy to understand the result.	Requires performance rating depending on the purpose. The analyst interfere the work.
Time study with video	Measure time for work sequences in running production. Method improvement.	Easy to perform. Does not interfere the work. Easy to involve operators.	Requires technology.
Work sampling	Pre-study for improvement projects. Measure the allowance time.	Easy to perform. The only way to measure allowances.	Design and analysis are complicated.
Predetermined time system	Design a norm time. Method improvement. Performance measurement.	The only way to design a manual work time. Objectivity and fairness. Detailed method analysis.	Requires training. Take long time to perform.

5. Measure time

5.1 Stopwatch time study

The stopwatch study is the most common way to measure actual time. It's popular because it's perceived as easy to perform. Everyone knows how a stopwatch (Figure 10) works, and everyone has access to a stopwatch function on their mobile phone. Using a stopwatch to measure machine time is not difficult. However, correctly performing a stopwatch study on manual work is not entirely straightforward. There are several aspects that make it more complicated than one might initially think, since the performance factor and the utilization rate factor affect the actual time. It's also challenging to maintain the quality of time standards based on stopwatch studies because it requires that the stopwatch study be completely redone for every change in product or process.

A stopwatch study can be used both to determine a standard time and to check and follow up a standard time that has been set with another method (for example, a predetermined time system). In both cases, the study needs to be able to separate deviations from the standard method, from disturbances. In the case where a standard time is being followed up, the deviation from the standard time will depend on the performance factor. In the case where a new standard time is to be determined, one must ensure that the performance factor is kept at the right level, which is 100% in most cases. Different measures to ensure this include:

1. Choose an experienced operator who is trained for the task.
2. Measure several cycles of the same task: 10 is a rule of thumb.
3. Identify and sort out cycles where disturbances or deviations in the method have occurred.
4. Use the average time for the remaining cycles.

If the performance factor varies from cycle to cycle, a performance rating needs to be made.

Figur 10. Picture of a stopwatch used in the past with so-called centiminute, meaning a minute is divided into one hundred parts. A base of one hundred makes it easier to do mental arithmetic. Foto: Peter Almström.

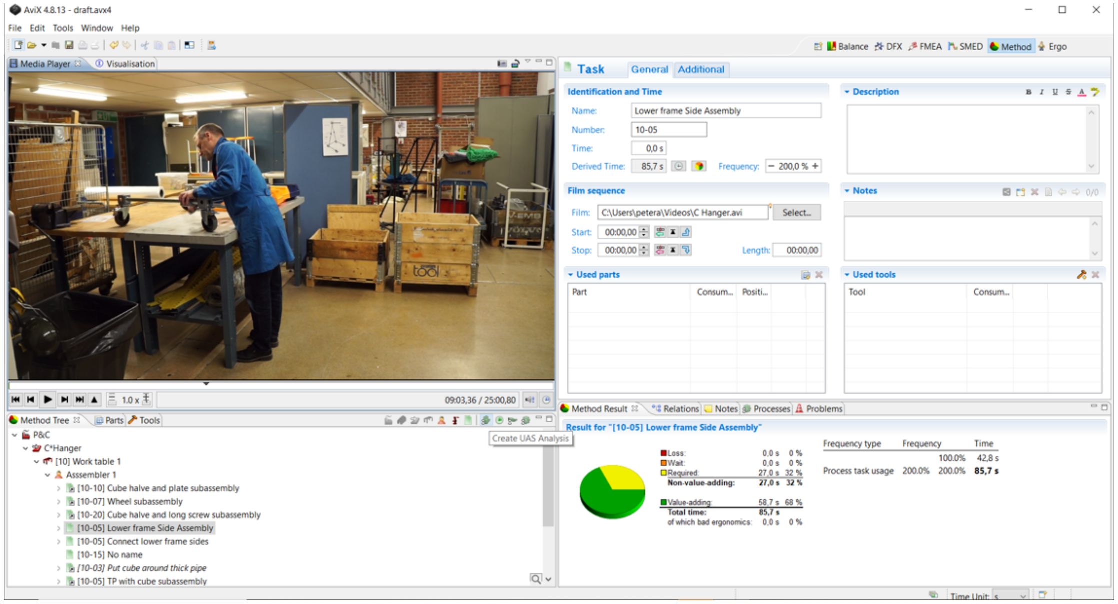
5.2 Performance rating

The performance factor needs to be calculated or assessed when time studies are conducted. The best way is to calculate it, which is done by dividing the planned time for a cycle, i.e., the standard time, by the actual measured time according to the time study. This, of course, assumes that there is a standard time.

$$\text{Performance factor} = \frac{\text{Standard time}}{\text{Actual time}}$$

If the measured time is shorter than the standard time, it means that the performance factor is over 100%. The standard time should be determined by a method agreed upon between the parties (company and trade union) at the workplace. The standard time obtained from an MTM (Methods Time Measurement) system means that the work pace will be at a sustainable level for the "normal worker," i.e., people who are physically near the middle of a normal curve over the population's physical performance ability (Maynard et al., 1948). The work pace according to the MTM standard is set so that the normal worker will not become exhausted or injured by the work. Of course, there are people at both ends of the normal curve who either cannot work that fast or who can work much faster. It is ethically questionable to agree on a performance factor over 100% (according to the MTM standard). Unless the company consistently manages to recruit staff with physical performance abilities above the average and who can also maintain the same level throughout their working life, there is a risk of harming the staff.

The other way to determine the performance factor is to make a visual assessment of the work pace. This is difficult to do and requires training and experience to achieve sufficient accuracy. If a time study with a stopwatch is conducted and there is no standard time available, this method must be used to determine a standard time.



Name: Lower frame Side Assembly
Number: 10-05
Time: 0,0 s
Derived Time: 85,7 s
Frequency: 200,0 %
Film: C:\Users\petera\Videos\C Hanger.avi
Start: 00:00,00
Stop: 00:00,00
Length: 00:00,00

Part	Consum...	Positi...

Tool	Consum...

1.0 x
09:03,36 / 25:00,80

- P&C
  - C*Hanger
    - [10] Work table 1
      - Asssembler 1
        - [10-10] Cube halve and plate subassembly
        - [10-07] Wheel subassembly
        - [10-20] Cube halve and long screw subassembly
        - [10-05] Lower frame Side Assembly
        - [10-05] Connect lower frame sides
        - [10-15] No name
        - *[10-03] Put cube around thick pipe*
        - [10-05] TP with cube subassembly

Result for "[10-05] Lower frame Side Assembly"

🟥 Loss:	0,0 s	0 %
🟧 Wait:	0,0 s	0 %
🟨 Required:	27,0 s	32 %
Non-value-adding:	**27,0 s**	**32 %**
🟩 Value-adding:	58,7 s	68 %
Total time:	**85,7 s**	
of which bad ergonomics:	0,0 s	0 %

Frequency type	Frequency		Time
		100.0%	42,8 s
Process task usage	200.0%	200.0%	**85,7 s**

Time Unit: s

Figure 11. Image from the user interface of AVIX. Below the video window is the activity hierarchy, and to the right is the analysis of an individual activity at the top with an overarching analysis below.

5.3 Video time study

A better alternative to using a stopwatch is to film the work being performed and then analyse the movie. To conduct a time study with video, specialized software is available, such as AVIX from Solme AB (Figure 11). The advantages of video time study compared to stopwatch time study include several points:

- It is easier to involve the operators in the analysis, and the analysis can be done in groups to gain immediate acceptance from those performing the work.
- Often, it suffices to film one cycle of the work since the footage allows identification of, for example disturbances, that should be excluded from the analysis.
- Filming disrupts the operator less than conducting a stopwatch time study, mainly because any discussion about what is performed and how operation steps should be divided can be done afterwards, when the analysis is carried out.
- It is possible to discover method improvements or deviations from the intended method through the movie. This could involve, for example, safety risks or ergonomic problems.
- A video of the work is beneficial for training new staff.

Just like with stopwatch time studies, the performance factor needs to be determined if the aim is to establish standard times. In AVIX, this is done by comparing with standard times from predetermined time systems integrated into the software. The downside of video time study is that being filmed can be perceived as an invasion of privacy, and there's a risk that personal data can be spread in the form of people appearing in the footage. This can be avoided if faces are not filmed or are masked. Another drawback is that the method requires technical equipment and software to perform.

5.4 Work sampling study

Work sampling study is a statistical method that, unlike a continuous time study, is based on sampling. The advantage is that observations are spread out over time, typically from a day up to a week, which makes it possible to measure activities that do not belong to the work cycle, i.e., allowance time. Work sampling studies are thus commonly used as a complement to time studies or on their own to identify different losses in the form of disturbances and other unwanted allowance times. The subjects of study are usually operators or assemblers, but the method is also suitable for administrative work.

The study can be conducted in two ways:

1. Random interval samples on a selected subject in a predetermined order or on all subjects in the study.
2. Constant interval samples on random subjects.

The constant interval option is preferable if the person conducting the study needs to plan other work between observations or achieve an even workload if the interval is short between observations.

The number of samples needed to achieve sufficient accuracy is given by the following formula (Zandin, 2001):

$$n = \frac{z^2 s(1-s)}{f^2}$$

where *n* is the minimum number of samples, the number of standard deviations *z* depends on the chosen confidence interval, the probability *s* that an activity will take place at the moment of observation, and *f* is the acceptable margin of error (standard deviation). With 95% confidence, $z = 1.96$ and with 99% confidence, $z = 2.57$.

To calculate the minimum number of necessary observations, a pre-study must first be conducted to get a rough idea of which activities should be highlighted in the study. Efforts should be made to group activities into as large and evenly distributed groups as possible because the least frequent activity (or group) will determine the total number of observations. If the smallest activity (or group of activities) of interest to highlight in the study is assumed to be 10% (*s*) and ±1% is an acceptable error with an acceptable confidence of 95%, then:

$$n = \frac{1{,}96^2 \times 0{,}1(1-0{,}1)}{0{,}01^2} = 3457{,}44$$

This means that at least 3458 observations are required for the least frequent activity of interest to be "true" within ±1% with 95% probability. If, for example, the smallest activity of interest is expected to be only 1%, the end result becomes nonsensical if the error is also ±1%. The relative deviation in this case is 100%. A lower margin of error must therefore be chosen depending on the purpose of the study and the requirements for precision. The recommended margin of error for different purposes is given in Table 5, although not all purposes in the table are relevant for work sampling studies. The value from the table is multiplied by the estimated value for the smallest activity of interest to determine an acceptable error.

$$f = f_{purpose} \times s_{smallest\ activity\ of\ interest}$$

For example, if the smallest activity of interest is estimated from a preliminary study to be 15% and the purpose is to find opportunities for improvement, then $f = 0.08 \times 0.15 = 0.012 = 1.2\%$. The point, therefore, is that the acceptable error depends both on the smallest activity of interest and on the purpose of the study.

5.5 Measurement with sensors

Automatic measurement means using some form of technical equipment with sensors and data processing that measures the time for an activity. This can range from a light sensor that indicates when a product passes by on a conveyor belt, thereby allowing the calculation of the product's cycle time by measuring the time between two products, to advanced AI algorithms that interpret movements and measure their time from streaming video in real time. Technological development is rapid in this area, and the technology is becoming both better and cheaper.

The simplest form of sensor is a button that the operator presses to confirm that the operation is completed. This is especially common in manually paced assembly lines. All assemblers at all stations must confirm before the assembly line moves forward. A more advanced variant is digital work instructions at each assembly station where the assembler confirms each work step by clicking on the screen (Figure 12). If the work instruction has a standard time, the planned time can be compared with the actual time for each cycle.

Figure 12. Digital instructions with confirmation in Casat from H&D Wireless AB. Photo reproduced with permission from H&D Wireless AB.

5.6 Times that are difficult to determine

Some activities are difficult to determine a planned time for, and it can also be challenging to measure an actual time for the same activities. There are several reasons for these difficulties:

1. Difficult to determine due to variation.

   a. The pick location for a component is random because of how components are delivered and packaged.

   b. Components or tools are in random locations due to a lack of standardization.

2. Difficult to determine due to complex geometry.

   a. The geometry results in many micro-movements, such as turns and grip changes.

b. The component is small, making the movements very small.

c. Many adjustments are needed to position an object.

3. Difficult to determine due to a lack of work standardization.

a. The variation in work tasks is too great for standardization to be rational. This might involve handicraft work.

b. When the activity is performed infrequently, it is probably not rational to have a standard for it.

c. Operators are allowed to have personal preferences in how the activity is performed.

The first action should be to standardize activities that can be standardized, not just to make measurement easier, but also for all the other benefits of having standardized work, such as ensuring quality, planning production, and facilitating improvement work.

Video time study is better than a stopwatch time study for measuring micro-movements, such as those performed during the assembly of cable harnesses. However, if there is randomness in how components are delivered, video time study might not work either. An alternative is to conduct a statistical analysis with a grouping method (slotting) (Freivalds and Niebel, 2009). This is based on conducting a large number of time studies on different cases, for example, cable harness assembly. From a Pareto diagram, groups can be identified and an average time for the group can be determined. The groups are delimited by some variable, for example, the number of contacts in the cable harness. Then, this variable can be used to determine a time for a new component without needing to perform more measurements.

6. Determine planned time

6.1 Predetermined time systems

There are many different predetermined time systems, and they are all based on the idea that all work can be broken down into a limited number of basic motions and that it is possible to determine a standard time for each of these motions. The standard times are based on human physical capabilities, that is, what a person can manage without being injured or exhausted. The times are determined based on statistical analysis of a variety of different tasks and represent average values for different individuals. The time for each element is affected by three variables: distance, force, and precision (Figure 13). Predetermined time analysis is necessary to be able to determine the planned time for manual work in the process planning phase. It is also the best way to perform a performance rating, by comparing the standard time obtained from the predetermined time analysis against the observation time from a time study.

The first predetermined time systems were developed as early as the 1910s. In the 1940s, MTM (Methods-Time Measurement) (Maynard et al., 1948) was developed, which is the foundation for the predetermined time systems that are dominant in the world today. The original system is now referred to as MTM-1 and forms the basis for a variety of simplified systems that build on combinations of MTM-1 elements. The elements in MTM-1 are very detailed, therefore the system provides high precision, but at the cost of taking a long time to learn and a long time to perform analyses. The most used MTM system in the world today is the German system MTM-UAS (Universal Analysing System). The MTM system most used in Sweden is called SAM (Sequential Activity- and Method) analysis (The Nordic MTM Association, 2024).

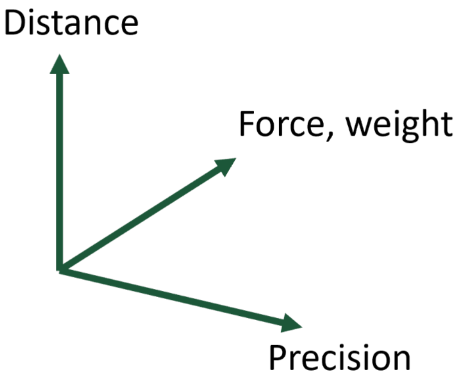


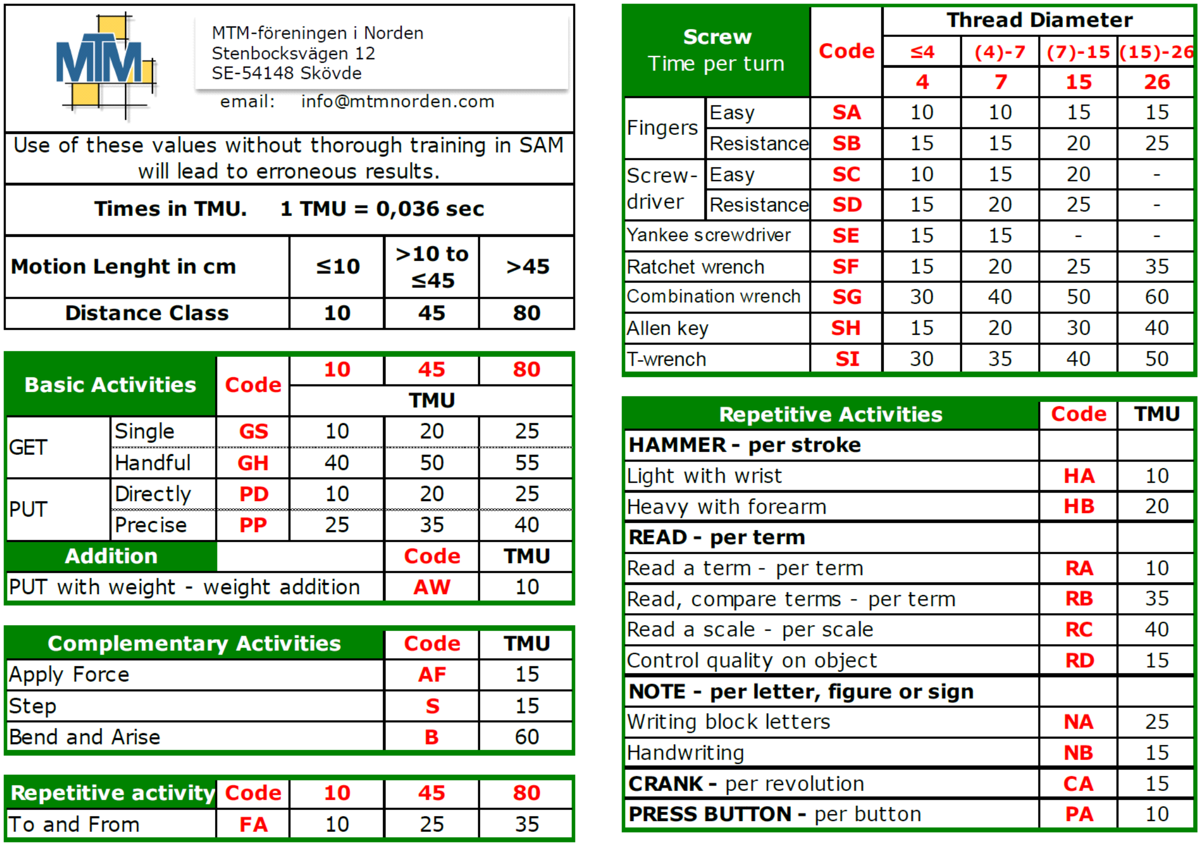
Figure 13. Three variables determine the time for motions.

6.2 SAM-analysis

Elementartidssystemet The predetermined time system SAM-analysis was developed in the 1980s by a group with representatives from various Swedish industrial companies within the framework of the Swedish Rationalization Association (*Svenska rationaliserings-föreningen*) (Luthman et al., 1990). The idea behind SAM is that the analysis with the method should be simple to perform. The analysis is carried out based on two natural sequences in typical industrial work: Handling of objects and Handling of tools. Handling of objects includes two activities: Get and Put, and Handling of tools includes: Get, Put, Use, and Return the tool.

In SAM, there are three distance classes: 10 cm, 45 cm, and 80 cm.

The data card for SAM (Figure 14) is divided into the basic activities of Get and Put, complementary activities such as Bend and Step, and a number of repetitive activities for some common activities performed at high frequency. The repetitive activities were created to reduce the error in the analysis that would have occurred if the analysis was made with Get and Put. The time on the data card is indicated in TMU (Time Measurement Units), which is one hundred thousandth of an hour. The time, for example, for a step is 15 TMU, which corresponds to 15×3600/100000 = 0.54 seconds. In an analysis, the times for all included elements are summed up in a protocol or in software. A certified analyst performs an analysis in about 25 times the studied time, which is much faster than, for example, MTM-1, but still represents a significant investment in work time. Certificates are issued by the Nordic MTM Association after a passed course. The purpose of the association is to maintain the MTM standard, and the board



MTM-föreningen i Norden
Stenbocksvägen 12
SE-54148 Skövde
email: info@mtmnorden.com

Use of these values without thorough training in SAM will lead to erroneous results.

Times in TMU. 1 TMU = 0,036 sec

Motion Lenght in cm	**≤10**	**>10 to ≤45**	**>45**
Distance Class	**10**	**45**	**80**

Basic Activities		**Code**	**10**	**45**	**80**
				TMU	
GET	Single	**GS**	10	20	25
	Handful	**GH**	40	50	55
PUT	Directly	**PD**	10	20	25
	Precise	**PP**	25	35	40
Addition				**Code**	**TMU**
PUT with weight - weight addition				**AW**	10

Complementary Activities	**Code**	**TMU**
Apply Force	**AF**	15
Step	**S**	15
Bend and Arise	**B**	60

Repetitive activity	**Code**	**10**	**45**	**80**
To and From	**FA**	10	25	35

Screw Time per turn		**Code**	**Thread Diameter**			
			≤4	**(4)-7**	**(7)-15**	**(15)-26**
			4	**7**	**15**	**26**
Fingers	Easy	**SA**	10	10	15	15
	Resistance	**SB**	15	15	20	25
Screw-driver	Easy	**SC**	10	15	20	-
	Resistance	**SD**	15	20	25	-
Yankee screwdriver		**SE**	15	15	-	-
Ratchet wrench		**SF**	15	20	25	35
Combination wrench		**SG**	30	40	50	60
Allen key		**SH**	15	20	30	40
T-wrench		**SI**	30	35	40	50

Repetitive Activities	**Code**	**TMU**
HAMMER - per stroke		
Light with wrist	**HA**	10
Heavy with forearm	**HB**	20
READ - per term		
Read a term - per term	**RA**	10
Read, compare terms - per term	**RB**	35
Read a scale - per scale	**RC**	40
Control quality on object	**RD**	15
NOTE - per letter, figure or sign		
Writing block letters	**NA**	25
Handwriting	**NB**	15
CRANK - per revolution	**CA**	15
PRESS BUTTON - per button	**PA**	10

Figure 14. Data card for SAM-analysis. The use of SAM requires training and certification. Reproduced with permission from the Nordic MTM Association.

consists of corporate stakeholders, academic experts, and representatives from the labour market parties.

6.3 Simulation with digital human models

Digitala Digital human modelling (DHM) is a technology with the potential to determine times for planned production. Currently, the technology is used to verify work methods and assess the ergonomics of workstations already at the design stage. The development of DHM tools started in the 1960s. Similarly to how CAD tools have evolved to become increasingly powerful, DHM tools have also become more functional and useful over the years. A clear difference between CAD and DHM is that DHM tools contain human models, where these human models, or manikins as they are also called, can be varied to represent diversity. The complexity and great variation of humans mean that there are many challenges associated with the development of DHM tools. So, despite the long-term progress in DHM development, there are still many challenges to be solved. One of these challenges is to predict sufficiently well how a person moves to perform a specific task. Related to this is the challenge of predicting how long it takes for a person to perform a task, i.e., not only to predict the movement itself but also its speed profile. In planning tasks, such as assembly, the strategy is usually the opposite, meaning that the manikin's work is planned based on a time determined with a predetermined time system. To make it easier and faster to create simulations, development is ongoing to allow giving manikins instructions at a higher (less detailed) level. Development is also driven to enable digital human models to predict times for tasks where time data is lacking, but this technology is still in the research stage. An example of DHM is the Swedish software IPS-IMMA (Figure 15).

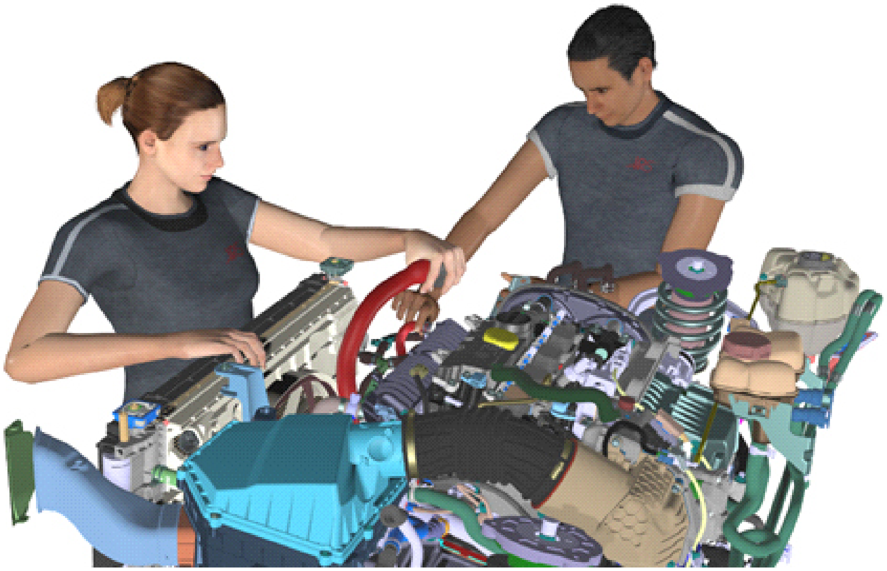


Figure 15. Manikins in the software IPS-IMMA from Industrial Path Solutions Sweden AB.

7. Time blocks

7.1 What are time blocks?

Time blocks are combinations of elements or operation steps into larger units. For instance, SAM-analysis can be considered a block system based on MTM-1 elements. SAM and other predetermined time systems are used as they are by many companies, but since the analyses require a lot of time and specialized expertise, there's a need for simpler block systems. This is especially true for smaller companies that do not have the resources to perform detailed analyses. Even larger companies with a wide variety in the products and variants manufactured can benefit from formulating time blocks to make the analyses more rational to perform. Company-specific block systems have existed for a long time. In English, they are often referred to as Standard Data (Zandin, 2001), which is rather non-descriptive. The novelty in this handbook is the systematics for how any company can create its own block system.

The blocks consist of activities that are timed using some method. Operation step division is an important tool for creating libraries of activities that cover all variants and are still efficient to use. The timing of the operation steps can be performed with all the methods discussed in this handbook. If the activities are performed today, methods for measuring actual time can be used; otherwise, methods for determining planned times need to be used. Since a complete database of operation steps needs to include both the activities the company performs today and activities likely to be used in future production, it is logical to assume that times from a predetermined time system are always needed. Times from a standardized predetermined time system like SAM offer several other advantages:

- The performance factor is determined by the system and at an agreed level.
- It is easy to modify operation steps by adding or subtracting elements.
- It is easy to explain how the time is set.

There will always be exceptions where predetermined time system is not the best method for determining time. The rational reasons have been discussed in section *5.6 Times that are difficult to determine*.

7.2 Precision and cost

In time determination work, there's always a trade-off between how accurate the analysis needs to be and how much time or cost can be spent on the analysis work. In the past, when piece rates were the prevailing form of wage, technicians spent several weeks or months of work, developing piece-rate standards. It was important that the precision was high so that the workers received the correct pay. Nowadays, when piece-rate wages are uncommon, it's probably not as crucial for most companies to have very high precision. For example, many companies in Sweden moved from using MTM-1 to using SAM when the wage form changed from piece rates to fixed monthly salaries. Since time standards are used for so many different functions that are important at different life cycle stages of a product and its production system, the requirement for precision varies a lot. To find improvements in ongoing production, high precision is not needed, while to optimize production plans with optimization algorithms, high precision is required for the optimization result to be useful. Table 5 provides recommended precision for different purposes. The recommendations are averages of several (>10) experts' opinions. The recommended precisions apply to high-volume production. For low volumes, there is probably less need for precision. The “minus” precision value can also differentiate from the “plus” value. For example, when quoting prices, a time resulting in overpricing is probably more acceptable than a too low price, from the selling company's perspective.

7.3 Time blocks with variables

Ett An operation step can have either a constant time or a variable time. The time is expressed with a time equation. In its simplest form, the time equations take the following expressions for the time T:

$T = K$, where K is a constant

$T = V \times K$, where V is a variable and K is a constant

A variable can be many different things, but by far the most common is the number of something, for example, the number of screws in an assembly. Variables can also be, for example, a distance measured in meters that determines the time for a weld seam or the area in square meters to be painted.

The total time for a time block is calculated by summing the time equations from all included operation steps. A time block can be as small as comprising just one element. A special case is the number of steps, with the variable “number” and constant time per step. It's often a good idea to have steps as its own time block because it's always a loss, and the number of steps will depend on the layout which can vary between different stations in the same factory where the same activities are performed. It can be practically difficult to standardize a layout, which would entail a standardized number of steps, due to space limitations.

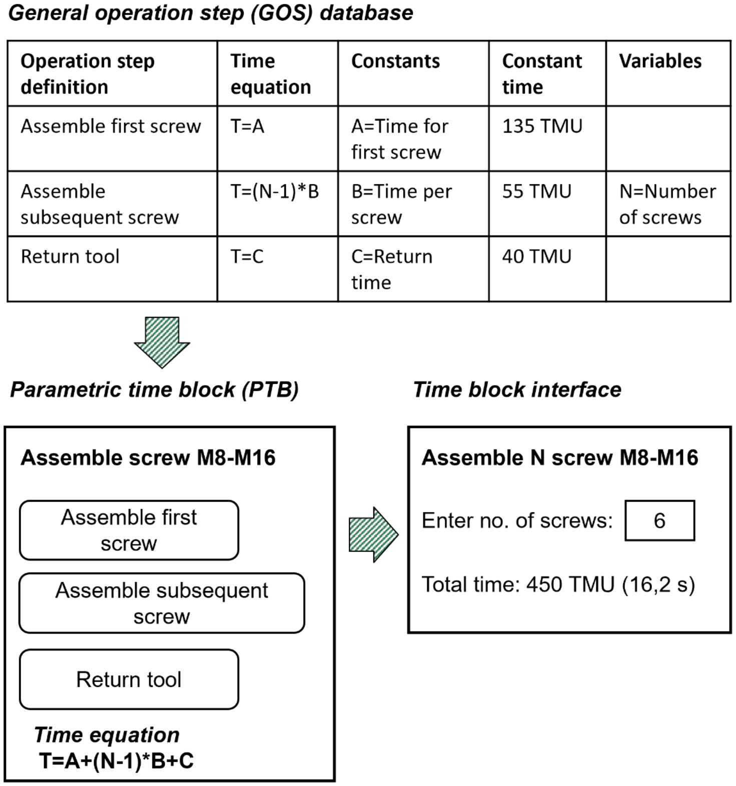
Table 5, Recommended precision for different purposes of time standards.

Purpose	Recommended precision ±%
Find improvement potential	8
Determine salary	1
Plan production (Scheduling, loading, sequencing)	5
Balance a line	4
Optimize production plan (with an optimization algorithm)	3
Calculate cost in early phases	12
Calculate cost for make-or-buy decisions	9
Calculate offer to customer	7
Make investment calculation	10

A significant opportunity for efficiency that is opened by the use of variables is to create simplified interfaces for the time blocks. Instead of the user needing to see which operation steps and time equations with constants and variables, that are included in the time block, it suffices for the user to see the name of the time block and understand from the name itself or a more detailed description, what activities the time block covers. Then, the user only inputs the values for the variables included in the time block and gets a final result in terms of time for the current combination of variables. An experiment conducted within the TIMEBLY project at Volvo Cars showed a significant potential for efficiency. The time for a completely new product on an existing assembly line could be determined in a quarter of the time using a time block interface, compared to the existing method. The time block interface was used by an inexperienced user, while the existing method was performed by an experienced time setter at Volvo Cars.

7.4 Example of time block and interface

How the time block interface relates to operation steps and time equations is illustrated by the example in Figure 16. The operation steps are defined with a descriptive name and


General operation step (GOS) database

Operation step definition	Time equation	Constants	Constant time	Variables
Assemble first screw	T=A	A=Time for first screw	135 TMU	
Assemble subsequent screw	T=(N-1)*B	B=Time per screw	55 TMU	N=Number of screws
Return tool	T=C	C=Return time	40 TMU	

Parametric time block (PTB)

Assemble screw M8-M16

Time equation
T=A+(N-1)*B+C

Time block interface

Assemble N screw M8-M16

Enter no. of screws: 6

Total time: 450 TMU (16,2 s)

Figure 16. Example of operation steps, time block, and time block interface.

are designed to be combinable, sufficiently universally usable, and, if applicable, repeatable. In the example, the operation step "Assemble subsequent screw" is repeatable, the other two are not. A time equation is determined for each operation step. All constants in the time equations are timed using the most suitable method. In this case, it involves simple movements that are probably best timed with a predetermined time system. An important point with the operation step database is that it's easy to create many variants, in this case for different screw sizes.

The variables are not assigned any value in the operation step database. Time blocks can then be constructed from combinations of various operation steps. In this case, all three defined operation steps are used to build the time block "Assemble Screw". Since it contains a variable, we can call it a parametric time block. A total time equation is calculated by summing the time equations of the included operation steps. Then, a time block interface can be designed where only the variable N number of screws needs to be entered to get a total time.

7.5 Design procedure for time blocks

According to the maturity model for TDM (Figure 8), the first step is to define all the times the company needs. This is done through an internal standard. It's equally important to standardize all other key factors that will influence the design of operation steps and time blocks, such as names of components, tools, and locations. The next step is to determine a standard syntax for formulating names of operation steps. A suitable syntax could be, for example, “[Verb] [Component] on [Component] using [Tool] at [Location]” or a more concrete example “Assemble Left Console on Frame using Screwdriver at Assembly Station”. After this, the actual formulation of operation steps can begin. It's appropriate to start with products that are frequently manufactured or that require a lot of manual work. Start with a few components and formulate Specific Operation Steps (SOS). Evaluate the similarities in the movements required and find commonalities that justify a General Operation Step (GOS). The size, i.e., how much time a GOS should encompass, is a trade-off between precision and cost. Use the four criteria to formulate operation steps correctly (Universally usable, Repeatable, Combinable, and Descriptive).

Continue with all components and aim to have as few SOS left as possible that cannot be generalized to GOS. The work will accelerate as more GOS are formulated. Constants and variables that control the time need to be defined for each operation step. The most important factor for having as few SOS as possible is to think more abstractly and not get stuck on the fact that, for example, it is a specific component being assembled, but rather to see the similarities in the movements that need to be performed. The final step is the timing of both GOS and SOS using the most suitable method. During the timing, problems may be revealed that lead to the formulation of new operation steps. The workflow can be summarized in the following procedure:

1. Define names for components, tools, machines, and locations.

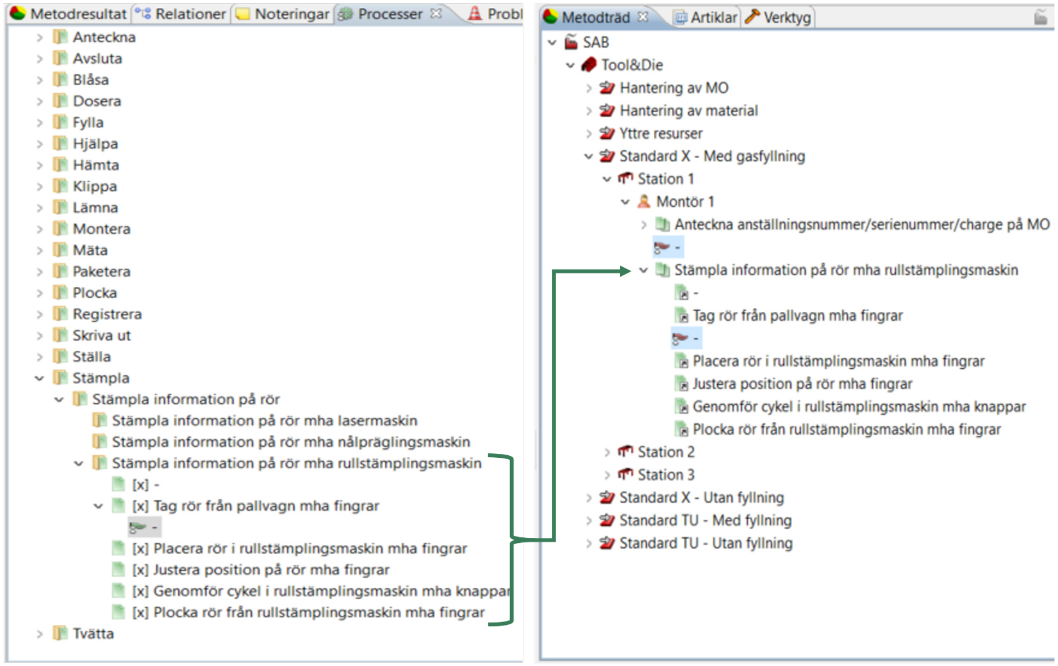
2. Determine syntax for expressing operation steps.

3. Start by formulating a number of SOS.

4. Find common movements and formulate GOS accordingly.
5. Use the four criteria to delimit GOS.
6. Determine how large GOS can be depending on precision requirements.
7. Aim to have as few SOS left as possible.
8. Define a time equation with constants and variables for each operation step.
9. Determine the time for GOS and SOS with an appropriate method.

7.6 Tools for designing time blocks

To follow the procedure in the previous section, both data availability and tools for documenting and storing data are required. The procedure will be very different depending on whether the products and components to be manufactured or assembled are in production today or if they pertain to future products. A company that has not previously formulated GOS and time blocks and is starting this work probably already has a production line; thus, the task involves observing and perhaps filming the ongoing production and discussing the method and workflow with the operators. If the work is not standardized, that needs to be addressed first.



Figur 17. Example (in Swedish) from Strömsholmen AB on the use of time blocks in AVIX. Reproduced with permission from Strömsholmen AB.Exempel från Strömsholmen AB på användning av tidblock i

Attempting to set time for work that isn't standardized is pointless.

In the TIMEBLY project, we initiated work to create operation steps and time blocks from scratch at three companies. The workflow on the previous page is primarily based on the experiences from this start-up work. At all three companies, we began by documenting the analysis in spreadsheets (such as Excel), which made it easy to build a structure. The iterations needed to formulate and reformulate operation steps are also smooth to do in spreadsheets. Once all components have been reviewed, the information from the spreadsheet can be transferred to a TDM software, such as AVIX. General Operation Steps are documented in the feature called Processes in AVIX. The example in Figure 16 shows how different GOS are combined into a time block without steps. Steps are then added in the planning of assembly at a specific station in the factory. Operation steps with times and completed time blocks can be stored in databases to be accessible by users at different locations within the company.

7.7 Time blocks for estimating costs

In the early phases of product and production development projects, there is a significant need to determine or estimate the planned time for various operations. Time blocks with simplified interfaces can be very useful here if the precision for the total assembly time of the new product is good enough. For example, someone making a decision on whether to purchase a pre-assembled component or to assemble the component in their own operations could use an interface configured by an expert.

The usual way to assess the cost of a new product in the early phases is to estimate the cost based on an existing product. If instead, the assembly time for a new product can be calculated based on combining operation steps into a time block, the uncertainty in each operation step can be assessed, and a more accurate estimate for the total cost can be calculated. A large majority of the operation steps will surely be usable as they are, and the uncertainty exists only in a small number of operation steps.

For a subcontracting company that continuously provides quotes to new and existing customers, time blocks with interfaces can also be useful. Technicians can create interfaces for a number of product categories with variables that will determine time and cost, that salespersons can use to calculate cost offers.

7.8 Time block for planning

In the operational phase of production, time standards are needed daily to determine production plans with scheduling, loading, balancing, and sequencing. A key issue is how different types of losses that occur in production should be handled in planning. The most common way is probably to allocate an allowance time factor, i.e., to multiply the ideal planned time by a factor, for example, 1.2 if 20% allowance time is assumed. This is thought to cover all types of P and U losses. However, this leads to the losses "disappearing" in the sense that they cannot be measured or improved. A better approach is the opposite, not to allocate any allowance time, but instead to be prepared to handle all disturbances that may occur. For example, balancing losses can be managed by having staff follow heavy variants through the assembly flow or by having extra staff that can be called in quickly in the event of a disturbance. Performance losses should not occur at all unless it involves a person who is new to the task; otherwise, everyone should maintain the agreed work pace.

Time standards in the form of time equations linked to operation steps should thus be kept free from all types of losses. If consideration needs to be given to disturbances in planning, it should be flagged in a special way by indicating that the added time is temporary. If an allowance factor is used, it is easy for it to be hidden and forgotten, which leads to allowance times being accumulated over time.

There are companies that use an individual sequence order for different combinations of product variants. Activities can be performed at different stations in an assembly flow depending on the sequence. This complicates the creation of GOS and time blocks based on them, if the purpose of the time blocks is to balance the flow. Clear principles for process planning are needed, and the operation steps need to be broken down into finer detail, probably down to the sequence level or even the element level according to SAM terminology. With such a need for flexibility and detail, it becomes impractical to create time blocks for balancing and loading planning, but it can still be meaningful in early phases, for example, for cost calculation.

8. Administrate TDM systems

8.1 Time data quality

One of the biggest challenges in Time Data Management is to maintain the quality of time data over time. Many types of changes and variations affect, or should affect, the time standards. Today, many companies have problems because the time standards in planning systems do not match the times in reality. Changes to the method in reality, for example, if a load and unload activity in a machine is automated, must be reflected in the time standards. But this does not always happen. Production may have an interest in "keeping" the improvements so that it becomes easier to meet production targets. There may also be a lack of expertise to study work and understand when assemblers have come up with a better way of working that should become the new standard.

There are also many types of variations that should not result in a change of planned times. It could be that staff are new and not fully trained, i.e., the P-factor lowers output, or there is a quality defect in incoming components causing U-loss. It's important to systematically analyze the differences between actual and planned time to understand if the difference is due to variation in M, P, or U. To make this work sustainable over time, three communication loops to and from the production function are needed (Figure 17). Production plans based on planned times are provided by the planning function. Actual

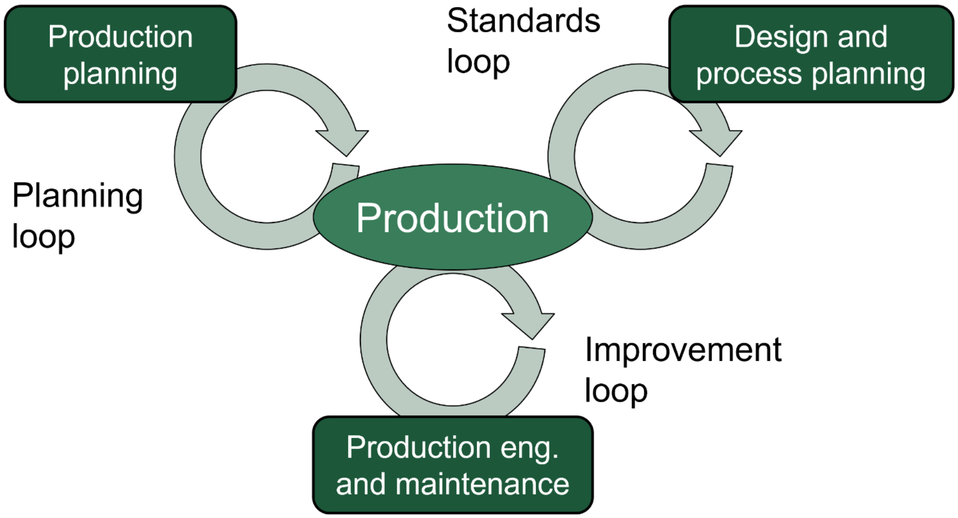


Figure 18. The three communication loops needed to ensure the quality of the time standards.

time must be measured in some way for each cycle or batch, and measurement data must be fed back to planning. Similarly, planned times developed by the process planning function need to be fed back from assembly if deviations are due to not following the method, for example, if the assembler has found a better method. Finally, deviations due to P and U losses must be fed back to the production support function that can do something about the causes of the variation. A P-loss, for example, could be due to unclear work instructions that are hard to follow.

8.2 Revise time standards

Every change of products or processes that affects how manual work is performed must lead to a change in the standardized method and alteration of the planned time. If the company's TDM system is not flexible enough, responsible staff will deprioritize updates, leading to deteriorating quality of time standards over time.

However, not all process changes are initiated by the company. It's natural for operators to find a better method over time, by for example reducing walking distances. The effect of this so-called method drift is that operators end up with spare time. It's common for them to use this freed-up time to "work ahead," meaning work in advance so the person can take a slightly longer break. Thus, the U-loss increases. The alternative is that the freed-up time is used to work slower, meaning the P-loss increases. Neither of these two alternatives is good for the company over time. But it's a dilemma because the company surely wants operators to find method improvements. The solution that benefits both parties is that it's agreed from the start how often the method should be revised, i.e., to measure actual time and compare the actual method with the planned method. If the method has changed, a new planned time should be determined to compare with the actual time. If there is a deviation, an analysis is needed to determine if it's P or U losses that constitute the deviation.

Many activities are not performed frequently, and the company may choose to allow a greater risk of deviation between planned and actual time. Freivalds and Niebel (2009) recommend different revision frequencies depending on the total time over a year for each activity (Table 6). For most value-adding operations, a revision once a year is probably a reasonable compromise between precision and cost.

Table 6. Recommended update frequency (Freivalds and Niebel, 2009).

Hours of application per year	Frequency of audit
0-10	Once per three years
>10-50	Once per two years
>50-600	Once per year
>600	Twice per year

8.3 Organisation for TDM

In large companies, a central organization responsible for developing and maintaining the TDM system over time is needed. This becomes especially important if the company operates various factories with different historical experiences of TDM and different local cultures regarding what is considered appropriate concerning, for example, performance levels or filming in production. The performance level determined in MTM is based on average industrial workers in the USA in the 1940s. It is debatable whether it is relevant today in all parts of the world, but what can be objectively stated is that human physiological development hasn't changed much over the last 80 years. What was then determined to be an acceptable performance level for the "normal worker" likely still applies today.

In global corporations, all parts of the TDM system must be translated into the local languages. Therefore, central organizations are also needed for each country or language area. In each factory, there need to be TDM experts who can roll out changes from the global organisation and who can capture method improvements coming from their own factory. It's crucial that the same standards for everything from nomenclature to principles for updates are maintained throughout the corporation.

Large companies can employ their own staff with the right TDM expertise, but this is more challenging for smaller companies. Likely, a consultant is brought in to create a time block system, but the work of standardization is unavoidable for the company’s own staff. In the end, it's a matter for the company's managers. If the top management doesn't think the quality of the time standards is important, the TDM system will eventually fail. To maintain quality, it's necessary to continuously train new people and allow staff to take courses to maintain competence.

8.4 IT-support for TDM

In a global corporation, all time standards should be stored in databases that provide access to the same data for all users. Many companies use spreadsheet software (such as Excel) to store time data. This is not a sustainable practice when the number of users is large or when users are spread across different locations.

There are several TDM software options that include various functions such as determining times, storing activity structures, process planning of stations and flows, balancing, and much more. Software developed by Swedish companies includes MBrain from Mtek AB, AVIX from Solme AB, and Casat from H&D Wireless AB. There is also software from countries like Germany and the USA with similar functions. Several of the large companies in Sweden have developed their own software with TDM functions that suit the company's specific needs.

8.5 Best practice TDM: Scania Time Setting System

Scania CV AB Scania CV AB currently uses a time block system, and the company's work with TDM has been an inspiration for the development of the general concept for time blocks presented in this handbook. Scania previously used predetermined time systems but stopped using them in the 2000s and switched to time studies with stopwatches and video. However, the work with the time standards became increasingly unsustainable. New product models and variants were introduced at an ever-faster pace, and maintaining the quality of the time standards was troublesome and time-consuming. For every change, it was necessary to film the work and conduct new time studies. There was also mistrust towards time setting from the workers and the union. Therefore, the company returned to using predetermined time systems and began using SAM. However, they wanted to make the analyses more rational and decided that the company would develop its own time block system based on combinations of SAM elements, Scania Time Blocks (STB). Moreover, Scania developed a completely new TDM system, including a new global organization, called Scania Time setting System (STS). This new system was introduced in 2016 and has been a great success. The quality of the time standards is much better, and they are no longer questioned by the staff. Analysing with STB is much faster than with SAM and is also easier and quicker to learn.

A key foundation for the success was that Scania was already proficient in standardized work. They already had global standards for how common tasks should be performed, called Scania Basic Skills. The step to time these standards and find generalizations that could be used to create STB was not far. The company now has a global database with all STBs administered by a central function responsible for maintaining the standard. Over a hundred time blocks are defined in STB, and more are added as more needs are identified. The latest addition is time blocks for internal logistics.

Scania uses AVIX for time determination, preparation, and balancing, and STB is implemented in the software. The principle for time setting is that STB should be used first and foremost, but for activities not covered by any time block, SAM is used primarily and, as a last resort, time studies with video or stopwatch.

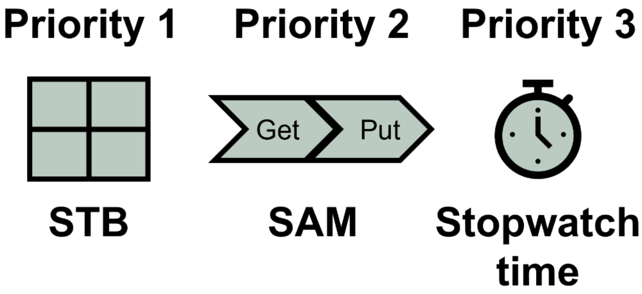


Figure 19. Scania's priority order for determining planned times.

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