From: *The Gilbreth Network,*
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Therbligs: The Keys to Simplifying Work

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The term may sound like a new computer term or some obscure part of the human anatomy, but Therbligs are actually the keys which unlock the mystery of the way we do work. In today's world of business, which requires longer and longer workdays of its employees, Therbligs might just be the method which can shave hours from a workday.

Therbligs comprise a system for analyzing the motions involved in performing a task. The identification of individual motions, as well as moments of delay in the process, was designed to find unnecessary or inefficient motions and to utilize or eliminate even split-seconds of wasted time. Frank and Lillian Gilbreth invented and refined this system, roughly between 1908 and 1924.

It is truly ironic that the most often requested Gilbreth material was for a subject that was never covered in any of their books. While the concept of the Therblig was born around 1908, it was constantly being refined and tested, as a tool; a very powerful tool.

In their writings from about 1915 through 1920, the Gilbreths begin to talk about 15 to 16 "motion cycles," but rarely named them all and didn't allude to any comprehensive system. Indeed, it was not until the late summer of 1924, shortly after Frank's death, that the entire Therblig System was presented in two articles in *Management and Administration* {August, 1924 pp 151-154; September, 1924 pp 295-297}. I have found some material in the Gilbreth collection, at Purdue, and some helpful refinements in books by Alan Mogensen, *Common Sense Applied to Motion and Time Study,* and by Dr. Ralph Barnes: *Motion and Time Study* [Seventh Ed., 1980, John Wiley & Son, NY]. These sources have been used in this article to provide an overview of the subject. [Note: while Motion Study and Therbligs have been reviewed and used by other authors, Mogensen and Barnes developed the most important improvements on the Gilbreths' original work.]

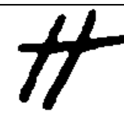
Before proceeding, it should be made clear that Therbligs had no relationship to Time Study, no matter what Taylor or his merry band of followers may have intimated, nor the later attempts of tying motion study to time study. As Frank Gilbreth put it: "....Taylor never did any motion study of any kind whatever." The very name, "Therblig", was created to show Gilbreth ownership of the term (the word being, Gilbreth spelled backwards with the exception of the "th").

Through various methods of Motion Study (Micro-Motion Study (movie film) and the Chronocyclegraph) the Gilbreths were able to examine the smallest of motions. However, to make the process uniform, between practitioners, they needed a method of categorizing the types of motions. The method would also have to be a system that could easily apply to all types of activities and yet still allow identification of what the Gilbreths viewed as unnecessary or fatigue producing motions. The resulting method included anywhere from 15 to as many as 18 Therbligs (which were added to by the Gilbreths and later authors).

The Therbligs would then be plotted on a Simo Chart (Simultaneous Motion Chart) along with the time each motion took. The sequences of motions of each hand were plotted, as was a foot, if used for pedal controls. Then, by examining the charts, one could determine which Therbligs were taking too long or which could be eliminated by rearranging the work. They could also identify periods of delay caused be either the tool/part layout. [Note: while time was measured, it was done so only to quantify the extent of each Therblig. The Gilbreths never assigned time values to Therbligs or to various tasks, as they believed that with an improved method of doing work, the shortest cycle time would naturally follow.]

Therblig Chart

The following table lists the Therbligs, along with their mnemonic symbols and standard colors for charting.

Therblig	Color	Symbol/Icon	Therblig	Color	Symbol/Icon
Search	Black		Use	Purple	
Find	Gray		Disassemble	Violet, Light	
Select	Light Gray		Inspect	Burnt Orange	
Grasp	Lake Red		Pre-Position	Sky Blue	
*Hold	Gold Ochre		Release Load	Carmine Red	
Transport Loaded	Green		Unavoidable Delay	Yellow Ochre	
Transport Empty	Olive Green		Avoidable Delay	Lemon Yellow	
Position	Blue		Plan	Brown	
Assemble	Violet, Heavy		Rest for overcoming fatigue	Orange	

*Hold---Therblig first appeared in Mogensen's book and later Dr. Barnes'.

The following definitions are a combination of those assigned by the Gilbreths, Alan Mogensen, Ralph Barnes and the author to provide the greatest scope for those attempting to use the system.

Search:

{icon suggested by an eye turned, as if searching}

The Search motion starts when the eyes and/or hand start to seek the object needed and ends just as the object is located. The Gilbreths stated that in a search, "....the time and attention required…varies with the number of dimensions in which the search is performed." A one-dimensional search might be locating a piece of paper on a desktop. A two dimensional search might be finding a light switch on a wall and the three dimensional search would be locating a hanging pull-chain for a light or fan. The Gilbreths also recognized that contrasting colors, shapes or embossed symbols could reduce the search function. This science has been expanded by the modern study of Human Factors Engineering. However, the classic example of the Gilbreths reducing Search was by arranging tools and parts in a physical sequence of use through the Packet Principle.

Find:

{icon suggested by an eye looking straight ahead at an object}

If there is an enigma in the Therblig system, Find is it. Dr. Barnes eliminated this Therblig, explaining that it was a mental reaction, at the end of the Search cycle. While other mental processes are included as Therbligs, this one is so momentary that the time taken for the Find function would be hardly worth measuring. It has been left in since in other applications it may be utilized. Find can be considered a demarcation line, denoting the end of the Search cycle. Even though we may not find frequent or essential use for this Therblig, it should be kept available, since it may become important in a future application of the system.

Select:

{icon suggested by an arrow aimed at an object, much the same as a computer cursor in form and intent}

This Therblig may be considered a part of Search. However, through usage by the Gilbreths, it was found to indicate locating an object from a group of similar objects. For example, an artist may Search for a box of colored pencils and then Select the proper color. If the Select function took too long, it might be wise to see how clearly the pencils are marked Do the shafts of the pencil denote the color either by copying the color on their surface or having it's name printed on the shaft?. Could this be aided by a pencil holder, where a bold bar of color aligned with the pencil location? Of course, good lighting is required to discern minor variations in color.

Another aspect that the Gilbreths included under Select was in picking objects that required a certain quantity. For example, let's say your job required you to fill bags with 100 nails each. Your count must be accurate, since the customer will complain if the count is low and management will fire you if your count is too high, giving away product. While you could count out each and every bag (1 to 100), you could save a great deal of time by having an accurate scale and finding the average weight of a bag of 100 nails. Then, you could "count" the nails by weighing them.

The important thing to remember is that the Search, Find and Select Therbligs may or may not be separate elements, depending entirely on the type of work being analyzed.

Grasp:

{icon suggesting by a hand poised over an object, ready to grasp it}

In simplest terms, Grasp is when the worker's hand grabs the object. The Therblig ends when the next Therblig, of Use or Transport Loaded, begins.

There are actually many aspects to Grasp, which the Gilbreths recognized and which continue to develop today. In this Therblig, the time taken is directly proportional with the ease of the grasp. For example, the more dimensions the object has, the quicker it can be effectively grasped. Frank Gilbreth observed that a sales clerk would put a slight crease in a cash register receipt so it rose above the counter surface, making it easier to pick up. Hot or cold objects could be grasped faster if they had insulated handles rather than using a rag or gloves to pick up an un-insulated handle.

The Gilbreths also recognized that when Grasp was a static position, such as holding a block of wood while a screw was being inserted, it should be eliminated by using a jig or foot-activated clamp or other holding device. They felt that the hand was a poor vise and caused great fatigue. Mogensen and Barnes separated this into a new Therblig (see Hold).

An important element in saving time was whether the initial grasping of an object would be the proper grasp for the Use or Assemble function. In this respect, Grasp has a close relationship with the Position and Pre-Position Therbligs.

However, in the body of the Gilbreths' work, the Grasp function was examined in detail, as to the type of Grasp (power grip, hook, precision or pinch grip). In their writings, they emphasized the advantages of the power and hook grips and tried to avoid precision and pinch grips. These findings are supported in current Ergonomics knowledge.

Hold:

{icon suggested by a horseshoe magnet holding a bar}

Dr. Barnes said this Therblig was "…the retention of an object after it has been grasped, [with] no movement of the object taking place." To clarify, we can call Hold a Grasp, of an object, occurring in one hand, while the other hand performs a Use or Assemble function. While the Gilbreths considered this part of Grasp, Mogensen and Barnes were correct in making it a separate Therblig, so as to alert the user to a negative Therblig, which should be eliminated. This is particularly true in using Therbligs in ergonomics, where static holding is an undesirable posture. By eliminating static Holding, you not only free up a hand for other uses, but also reduce overall fatigue.

Transport Loaded:

{icon shows a hand cupped, holding an object}

This Therblig begins after Grasp where the hand is doing "work" by moving the weight of an object, and ends when just before the Release Load, Use or Assemble Therbligs. The main objective of this Therblig is to reduce the distance and subsequent time involved for transport.

However, an obscure note in the Gilbreth papers has even more important ramifications in applying Therbligs to Ergonomics. Gilbreth sometimes included numbers, indicating the weight of the object inside the "fingers" of the mnemonic symbol. This information, combined with reach distances, can identify possible problems leading to strains.

Distances and effort can be reduced by the old Gilbreth maxim of making gravity work for you, by having sloped bins. This type of storage bin also would improve the Search function, since objects would be easier to see.

Transport Empty:

{icon shows an empty hand}

This is the motion of moving the unloaded hand from the point of Release Load to the next function within the sequence. It can also be considered the hand motions involved between Select and Grasp, where the eye identifies the object and the hand moves towards it to grasp. This Therblig is a non-productive one, and as such, should be kept to a minimum.

One could reduce the length of Transport Empty by placing the release point close to the Assemble point, such as a gravity chute located by a hole in the work surface. In many instances, reducing the length of either Transport Therblig can reduce the extent of reaching required; a sound ergonomic principle.

Position:

{icon suggests an object, such as a pen, being placed in the hand, ready to Use}

This motion is the act of placing the object in the proper orientation for Use. For example, a screw lies on the workbench in a horizontal orientation, but is to be used in a vertical position. Positioning would occur when the screw is picked up and rotated into the vertical position for inserting it into an object. This function may be completed during Transport Loaded or be a totally separate Therblig.

This Therblig, like Hold, is one, which can completely be eliminated by the design of the work place. If a tool or part is placed such that it is stored in the proper position for Grasp, the object doesn't have to be reoriented. Take, for example, the use of a pen. If kept in the shirt pocket, you must remove it with the tips of the thumb and index finger, by the opposite end of the point. If the pen were lying flat on the table, people would generally pick it up by the mid-section. In each instance, the pen must be reoriented into the proper writing Position before it can be Used. However, if the pen were in a holder, angled back toward the person, they could Grasp the pen in the same orientation as the Use position, thus never having to change Position. See also Pre-Position.

Assemble:

{icon shows several items (lines) placed together}

This Therblig starts when two or more parts are placed together (a peg into a hole) and ends when either the assembled object is Transport Loaded or when the hand reaches for another part (Transport Empty). Long lengths of time for this Therblig open numerous possibilities for improvement. For example, in the case of placing a peg in a hole (each of the same diameter), both Gilbreth and Barnes found that your can speed assembly by increasing the size of the target. In the case of the peg, assembly time will be significantly shorter if the holes are countersunk, which aids in guiding the peg into the hole.

The Industrial Engineering field has developed an infinite number of ways to reduce assembly time. For example, using “key-ways” to mark the proper orientation of a part reduces errors and the subsequent time to correct them.

Use:

{icon is simple the letter U---for Use}

This Therblig should not be confused with Assemble. Use is when an object is being operated as it was intended, and typically denotes a tool. For example, we would Assemble a drill by placing a drill bit in the chuck and tightening it, but we Use the drill to bore holes. Operation of controls on a machine would also be considered Use. Alan Mogensen later categorized Use as the Therblig requiring the most skill.

Disassemble:

{icon shows Assemble symbol with one part removed}

This motion is essentially the opposite of Assemble, depending on the circumstances. While it could be used where a mistake was made in Assemble, it could also be the act of removing a part from a jig or clamp, which held the part during the Use or Assemble motion.

Again, using our drill and bit example, we Disassemble when we unscrew the chuck and remove the bit. Assemble would start when we inserted the next bit needed. In this example, if two different sized drill bits were required to complete the task, the time involved for Assemble and Disassemble could be reduced by either having two drills (each with a different sized bit) or by substituting a drill with a keyless chuck.

Gilbreth, for example, showed that the Disassemble step could be eliminated in the case of a punch press, where the part was normally removed by hand and placed in a box. He had an air jet installed, near the base of the part, which activated on the upstroke of the punch press, dislodging the part and letting it fall down a chute to a waiting box.

The Disassemble Therblig should always be examined for possible elimination. If an item must be partially disassembled for Inspection or for addition of other parts, the order of these operations should be reviewed to eliminate unnecessary steps.

Inspect:

{icon suggests a magnifying glass}

This Therblig involves the act of comparing the object with a predetermined standard. This act can employ one or all human senses, depending on the object and the desirable attributes being checked. The inspection can be for quantity (amount or size) or quality. The motion starts when the item is first picked up or viewed and ends when it is either released or used in assembly.

Again, the extent of time involved should be examined and reduced if possible. For example, Frank Gilbreth observed employees at a light bulb manufacturer picking up the bulbs and holding them up to the lights in the ceiling, to see if the filament was properly attached. Frank placed a light behind a translucent screen in front of the worker, which allowed them to check the bulbs more easily.

Inspect would also come into play as part of the Select process. As a youngster, I used to love putting Heathkits together. In their assembly manual, they suggested that you take the time to sort out the various sizes and types of parts using a muffin tin. This brief investment in time virtually eliminated the Inspect function.

Of course, the issue of inspections can also cross over to the whole Quality Management issue. Here, we can defer to the writings of Doctors Juran and Deming.

Pre-Position:

{icon suggests a bowling pin being placed into proper position – obviously developed before automatic pin setting machines}

This is the motion of replacing an item in the proper orientation for it's next Use. In the example of the pen being in a holder on the table, the act of replacing the pen in the proper Position for its next use would be Pre-Position. Like Position, it can be performed during Transport Loaded.

Frank Gilbreth's favorite example was when a pool shot is planned so that the cue ball ends up in a good position for the next shot. Another Gilbreth application was where the Pre-Position function was done before it reached the worker. He developed numerous Packets, where parts were place in the proper Position for Grasp and in the proper order for assembly, thus reducing the Select motion as well.

However, where a workbench has been set up with tools properly positioned for use in assembly, the Pre-Position Therblig becomes an important measurement. If the time to Pre-Position a tool (after Use) is longer than Select, Grasp and Position motions, then one should consider improvements in the way Pre-Position is done. For example, if placing a drill back in its holder takes more time, the type of holder should be modified.

Release Load:

{icon suggested by a hand with an object poised to drop}

This motion involves releasing the object when it reaches its destination. The actual time taken will be fractions of a second and would vary with such things as if it were being Pre-Positioned or if the release was merely down a hole, into a gravity chute. Caution must be taken in solely working towards short release times. For example, it may be quicker to drop the part into a bin, but what about the next station/operation? Do they have to spend time Positioning the part? How does the time compare between the various options? We know that merely dropping the pen, when you are finished writing, may involve unnecessary Search and Position motions, which clearly take longer than the time saved with a quick Release.

Unavoidable Delay:

{icon suggested by a man bumping his nose unintentionally}

This Therblig is measured from the point where a hand is inactive to the point where it becomes active again, with another Therblig. These delays were defined by Gilbreth as being out of the control of the particular worker being studied. They could involve a lack of raw materials being available or repair of a tool, etc. While these delays might be dealt with by the overall factory/business system, they were not considered the responsibility of the individual operator.

The Gilbreths felt that these time periods should be used for rest. Time and again, they warned management that they should never chastise a worker for resting during these periods. It could be just as fatiguing for the worker to try and "look busy" as it was to do actual work. Since the whole idea was to eliminate fatigue, the workers should be allowed to take advantage of these periods.

Avoidable Delay:

{icon shows a worker intentionally lying down on the job}

This counterpart to Unavoidable Delay involves inactive time the worker encounters over which he/she has control. For example, if the worker is required to do inspections of their tools and report problems, and the result is a tool that breaks in the middle of the shift, the worker is responsible for the delay.

Avoidable Delays can also occur with an individual hand or body part, which remains idle while another is working harder than needed. For example, if the person is Selecting parts for Assembly, exclusively with one hand, while the other remains idle, the work is not only slowed, but the hand being used is becoming more fatigued. In many cases, the solution, in the use of both hands, can be solved by encouraging the worker to become more ambidextrous.

Plan:

{icon shows a worker with fingers on head, thinking}

This Therblig is a mental function, which may occur before Assemble (deciding which part goes next) or prior to Inspection, noting which flaws to look for. The extent of the use of Plan varies greatly with the type of job performed. However, in routine jobs, the time spent in the Plan Therblig should be kept to a minimum through arrangement of parts and tools.

Plan time, by the worker, can also be eliminated by the system. For example, for those items we purchase where "some assembly is required," our Plan time is greatly reduced when the instructions list out the tools needed for assembly.

Looking at this another way, Plan could also be considered another type of Delay, where a thought process is occurring rather than merely remaining idle. In this case, if the Plan Therblig takes a certain degree of time, there is no reason the worker's body couldn't be in a rest mode.

Rest to overcome Fatigue:

{icon shows a person resting in a seated position}

This Therblig is actually a lack of motion and is only found where the rest is prescribed by the job or taken by the worker. In the Gilbreths' scheme of Fatigue Reduction, after you had eliminated all unnecessary motions and made necessary ones as least fatiguing as possible, there would still be the need to rest.

At first they devised complicated work/rest schedules, recognizing that short, frequent rest breaks were more beneficial than longer, less frequent rest breaks. However, these schedules could be difficult to enforce or achieve, as they depended on the worker remembering to take their breaks and for how long.

For our purposes, it should be remembered to include rest breaks in measuring the overall time it takes to complete a job. We should also look to "enforced" rest breaks, which, for example, on an assembly line could be achieved by either shutting down the line at given intervals or by having blank or dead sections on the conveyor, where no product was placed. This type of enforced break could be applied today, to computers.

With reports of computer fatigue being commonplace in the office, why couldn't there be a timed function that would freeze the computer for five minutes every hour (this is the break frequency commonly recommended in Ergonomics and interestingly enough, the same frequency recommended by the Gilbreths for typists)?

The Next Steps:

While there was always the temptation, during the initial analysis of these data, to start making recommendations, the Gilbreths warned against such haste. They instead advised that the entire existing work method should be fully analyzed.

The Simo Chart would clearly show what sequences took the longest. While the motions taking the longest times should be reviewed for possible improvement, the Gilbreths again warned against overlooking even the smallest times, if they could be eliminated. As they pointed out, if you could reduce the motion times of even the three smallest motions, by let's say, a total of 6 seconds per cycle, and if the job were repeated 500 times per day, those simple changes would amount to a saving of over 4 hours per week. If there were just 5 workers doing this job, at $10.00 per hour, the resulting savings would be over $200.00 per week, or more than 10% of the base wages.

Viewed from the workers' perspective, they could reduce their workday by 10%. If paid on piece rate, they could increase their income by the timesavings. In this day of ever-increasing workdays, where the eight-hour day seems like a fond memory, it gives us hope that there is a system that will help us be truly efficient.

While there are always little tricks of the trade designed to save time, with the use of Therblig analysis, and the Simo Chart, the actual net savings can be quantified. By eliminating unneeded motions and reducing the effort and time of necessary operations, the rate of production can be increased without speeding up the pace of work.

If you begin to conduct work analyses using Therbligs, you will begin to see certain patterns emerge. Some Therbligs will show relationships to one another, within the various work processes. An employee of the Gilbreths, Paul M. Vanderhorst conceived the idea of the Therblig Wheel, which had a rim, spokes and hub made up of Therbligs, with Use at the hub and opposite spokes being related motions. This is a useful tool in learning of the relationships of various Therbligs, but, depending on the operation analyzed, can have different interpretations.

After the analysis was completed, changes would be made in the work process to either reduce or eliminate the time involved in various Therbligs. When the Gilbreths first started with these improvements they came up with sometimes elaborate schemes of teaching the worker a new set of precise motions. In one such scheme, for bricklaying, based on ease of reach, Frank Gilbreth went so far as to display numbered diagrams of brick walls, showing the order and places in which bricks should be placed. In addition, the Gilbreths also changed the layout of work, using modifications designed to improve efficiency.

Years after one of their first efforts, they returned to the same factory and found that while the workers had almost all forgotten the motions taught, the production output remained at the same high level it had after the improvements were first made. They found that this was due to one important factor. While the workers may have forgotten the motions taught to them, the re-design of the work place, tools and parts layout continued to reduce the time per unit produced.

The Gilbreths later stated that the best way to improve the efficiency of motions was to engineer efficiency into the system. With tool racks, parts sorted in easy to reach bins, gravity chutes and the like, efficient motions would naturally follow.

Conclusion:

The Gilbreth System of Therbligs broke important ground in the study of work and work methods. Indeed, with the addition of two Therbligs (Hold and Plan) and the elimination of one (Find), the system remains relatively unchanged from when they first developed it. But the Gilbreths always wanted the Therblig system to be a work in progress, which is just what has happened.

Therbligs have been used for every form of work imaginable. Indeed, the system has been applied to work in robotics and interactive computer systems. Where not used directly, the method has been a model for systems analyzing other aspects of work.

The RULA system measures body posture and movement, by analyzing videotape of workers and using check boxes to denote body posture during various tasks. It bears striking similarities as to how Therbligs were used on the Simo Chart.

At Penn State University, their Industrial Engineering department has developed checklists for analyzing work, including Motion Analysis, Workstation Design and Therbligs. These checklists are comprised almost entirely of suggested remedies proposed by the Gilbreths. [note: you can find these checklists at: http://www.ie.psu.edu/courses/ie327/forms.htm]

In the field of Human Factors Design, the application of Therbligs is limitless. Here the Search and Find speed are of prime importance, when it comes to control design for critical systems.

In Ergonomics, where reducing fatigue and injury producing motions is a main goal, the Therblig System is invaluable. Indeed, as motion analysis systems have become more sophisticated and expensive, Therblig analysis (which requires only a video camera and some training) is one of the most cost-effective tools available.

In computer software design, the possible use of Therbligs remains largely uncharted territory. For example, if, when using the mouse, the Search and Select Therbligs could be reduced, in both time taken and frequency of pointing and clicking, computer efficiency would improve at the same time we reduced the exposure to fatigue from using the mouse (a proven source of cumulative injuries). If we Pre-Positioned text or functions, using single-key Macros, again, Use and Assemble times would be reduced.

From these few examples, you can see that the Therblig method is a work in progress, with many new and yet to be explored applications. Frank Gilbreth was always referred to as a "thought detonator," presenting ideas for others to develop. With the Therblig System, he and Lillian Gilbreth created an atomic bomb.