Operation technology management

Learning Objectives To understand the purpose of work measurement and methods that organizations use to perform time studies, calculate standard times, and estimate the proportion of time spent performing different types of tasks. To understand the concept of learning curves and how they can affect business decisions, and to learn computational methods for estimating aggregate production times in learning environments. “ John Bracket has filed a lawsuit against us, George,” stated Paul Cumin, the vice president of operations for the State Rehabilitation Services Commission (SIRS).

George, you are Bracket’s manager. So what happened? He claims you raised his daily productivity quota for processing invoices from 200 to 300. ” “ Paul, I did raise his quota to more closely match the other employees. Bracket is always late for work, plays games on the computer, violates our dress code, and is generally disliked by his peer employees,” responded George Davis, Brackets Immediate supervisor. “ Is there any logic or numerical basis for your increasing his quota? ‘ Paul asked him. As he left the room, George responded, “ Paul, I’ll get my work study data out, review it, and get back to you this afternoon. “ Jim, it takes 2, 000 hours to build each electrical generating turbine, so if we have to build ten, It takes 20, 000 hours. We should plan our budget and price per generator based on 20, 000 hours,” exclaimed Pete Jacobs, the vice president of finance. “ No, Pete. According to my calculations, it will take only 14, 232 hours to build ten turbines and our total cost and budget will be much lower than you think,” said Jim Conner, the vice president of operations. “ How do you get such crazy numbers? ” replied Jacobs. Time standards represent reasonable estimates of the amount of time needed to other operations expert.

The first episode highlights the importance of time standards in setting Job performance standards, and how they can affect nongovernmental relations. Bracket’s new processing quota of 300 invoices per day may or may not be a fair Job performance goal, but the only way to find out is through careful work measurement analysis. You will have the opportunity to analyze this situation in more detail in one of the cases at the end of this chapter. In the second episode, Jacobs cannot understand the discrepancy between his estimate of 20, 000 hours and Concern’s value of 14, 232 hours to produce a batch of turbines.

The assembly of electrical power-generating turbines is a complex Job with labor costs for engineers and production employees approaching $100 per hour. Obviously, a difference of 5, 768 hours can be significant in terms of cost, budgets, and pricing decisions. Where did Conner get his figure? Moreover, why should the total time to produce ten turbines be less than 10 times the time to produce the first? Many work tasks show increased performance over time because of learning and improvement. Failure to recognize this can lead to poor budgeting, erroneous promises for delivery, and other bad management decisions.

In this supplemental chapter we introduce work measurement, standards, and learning curves, and how they are used in business. Most large corporations develop standard times for routine work tasks using work measurement. They are used in setting Job performance standards, establishing recognition and reward programs, and for compensation incentives. Valid standard times are vital to accomplishing most of the process design and operations analysis methods described in this text.

Smaller businesses, especially service businesses, usually do not have such standard times for their work activities and tasks.

However, if one seeks to improve operations, analyzing work and determining standard times for key work activities and processes is a crucial first step. Supplementary Chapter A: Work Measurement, Learning Curves, and Standards WORK MEASUREMENT Operations managers are interested in how long it takes to create an output or outcome, or equivalently, how much can be produced over a certain length of time. Work measurement is a systematic procedure for the analysis of work and determination of times required to perform key tasks in processes.

Work measurement leads to the development of labor and equipment time standards that re used for estimating work-force and equipment capacity, establishing budgets, determining what new work procedures will cost, evaluating time and cost trade-offs among process design alternatives, establishing wage-incentive systems, monitoring and evaluating employee performance and productivity, and providing accurate information for scheduling and sequencing. Learning Objective time spent performing different types of tasks.

Work measurement is a systematic procedure for the analysis of work and determination of times required to perform key tasks in processes. Without accurate time standards it is impossible to perform these tasks. For example, the process of assembly-line balancing, discussed in Chapter 7, requires accurate estimates of the standard time required to perform each task or work activity. Standard times are management’s anchor in an uncertain

operating environment. To establish usable standards, work tasks and activities must be carefully defined and studied.

Thus, Job and process analysis should precede work measurement. How long it takes to perform a task depends on the worker’s pace, operating conditions, and work method. Normal time is the expected time required to perform some work activity at a normal pace, under normal operating conditions, and using a prescribed method. By a normal pace, we mean a pace that can be consistently performed by the average employee without undue fatigue under normal operating conditions. The prescribed method to perform a task is usually developed by industrial engineers who identify the most efficient and safest procedure.

However, not everyone works at the same pace, and people may either slow down or speed up their effort when they are being observed. Thus, observed times must be adjusted by a factor that accounts or the worker’s effort. Normal times are calculated using the following equation: Normal time Observed time Performance rating factor TO PRO (A. L) Normal time is the expected time required to perform some work activity at a normal pace, under normal operating conditions, and using a prescribed method.

The performance rating factor (PRO) is a Judgment made by the person doing the time study as to whether the employee is working at the normal pace (that is, 1. 0 or 100 percent), below the normal pace (that is, less than 1. 0 or 100 percent), or above the normal pace (that is, greater than 1. 0 or 100 percent). For example, a PRO of 115 percent indicates that work is being performed at a pace that is 15 percent above normal. Typically, three or

more highly trained work study analysts make these judgments independently and then the average PRO is used in Equation (A. L).

For example, if work study analyst A rates an employee at PRO 1. 2 and an observed time of 2. 5 minutes per unit, B rates the same employee at PRO 1. 0 and an observed time of 2. 2 minutes per unit, and C rates the same employee at PRO 0. 9 and an observed time of 2. 1 minutes per unit, then, using Equation A. L, the normal time is 2. 363 minutes per unit (1. 2. 5 1. 0 2. 2 0. 9 2. 1)/3. Normal times must also be adjusted for personal time and unavoidable delays. Allowances include time for labor fatigue and personal needs, equipment breakdowns, rest periods, information delays, and so on.

Most allowance factors are in the range of 10 to 20 percent. Standard time is normal time Normal time (1 Allowance factor) (A. 2) Allowances include time for labor fatigue and personal needs, equipment breakdowns, rest periods, information delays, and so on. Standard time is normal time adjusted for allowances. MM SPOTLIGHT Work Measurement Activities in Roller Coaster Maintenances A popular roller coaster called the Runaway Mine Train (RAM) requires extensive inspections, maintenance, and repair to keep it running and earning revenue.

During peak season, the RAM is expected to operate 16 hours per day. Each part of the RAM, from structural steel uprights to the bearings in the wheels, must be inspected and well maintained. All RAM daily work tasks are grouped into work activities such as complete train inspection, track inspection, electrical inspection, cleaning the trains, and vehicle inspection. Each work activity is assigned a craft employee such as a rack and vehicle

machinist, electrician, sound engineer, custodian, oilier, software and computer operator, and so on.

Sixty-one distinct Jobs existed for this attraction but only the Jobs related to inspection, maintenance, and repair were to be time studied. A sampling plan was established and the data collected. Once time standards were determined for all interrelatedness tasks, the number of employees required was computed. Preventive maintenance was done each Wednesday and required additional changeover or setup time. Two teams were established, each with four people. One team worked Sunday to Wednesday and the second team from Wednesday to Saturday. The two teams overlapped on Wednesday for one-half day to get all preventive maintenance done.

Work measurement information and analysis plays a major role in achieving the objectives of operating safety, efficiency, and profitability. For example, if the normal time is 2. 363 and an allowance factor of 1. 2 is used, the standard time is 2. 836 minutes per unit. The performance rating factor and allowance factor are based on human Judgments, and therefore, the procedure for establishing standard times must include audits, third-party reviews, and extensive raining and retraining of work-study analysts to keep them properly calibrated.

Videotapes of employee work activities are often used to train work-study analysts (also see MM Spotlight: Work Measurement Activities in Roller Coaster Maintenance). Time Study Methods Time study is the development of a standard time by observing a task and analyzing it with the use of a stopwatch. Time study use of a stopwatch (see MM Spotlight: Job

Description? City of Phoenix, Arizona). The general approach to time study can be described as follows. 1 . Define and evaluate each task and activity.

This includes determining what level of detail is best for time study measurements, and then grouping or separating tasks accordingly. 2. Measure and record the time needed to perform each task or activity over a number of cycles. A trained observer with a stopwatch usually does this. A number of observations should be taken to account for variability in performance. Assuming that the distribution of task times is normally distributed for each task, the number of cycles that should be observed is determined statistically by the sample size (n) formula, Equation (A.): n (z 2 2/E 12) (A. 3) where z 12 is the value of the standard normal distribution having an area of 12 in the per tail, is an estimate of the standard deviation, and E is the desired sampling error. When timing a work activity with multiple tasks, the general rule is to take the largest sample size estimate from Equation (A. 3) for all tasks. Rate the employee’s performance of each task or activity. As noted, rating human performance accurately requires considerable training. Use the performance rating and Equation (A. L) to determine the normal task time.

The sum of those task times is the normal time for the entire work activity. Determine the allowance factor for the work activity. Determine the standard time using Equation (A. 2). An operations activity chart is a detailed analysis of work motions performed for a manual task. To illustrate time studies, we will consider a simple manual assembly process. Exhibits A. L and A. 2 show a faucet assembly and an operations activity chart, which provide the basis for developing the time study. An operations activity chart is a detailed

analysis of work motions performed for a manual task. M SPOTLIGHT Job Description? City of Phoenix, Arizona The city of Phoenix, Arizona posted this Job description for an “ operations analyst. ” The Job is to design, conduct, and participate in major work standards and systems analyses covering a wide variety of government functions. Considerable flexibility is allowed in this Job for designing and conducting each study. Assignments are comprehensive and entail interactions between major government and civic government officials, so writing and presentation skills are essential. Evaluates office machines and office or heavy operations equipment relative to quality, price, and determination of best equipment; Organizes, authors, and presents oral and written research reports; Identifies work elements in detail and develops complex flow charts, work standards, and work method improvements; Demonstrates mutinous effort to improve operations, decrease turnaround times, streamline work processes, and work cooperatively and Jointly to provide quality seamless customer service.

Operations Analyst for City of Phoenix, Arizona Essential Job Requirements: Designs systems, procedures, forms, and work measurements to effect methods improvement, work simplification, improvement of manual processing, or for adoption to computer processing; Designs control reporting systems for use in unit measurement for evaluation of performance and for determination of staffing levels and recommends staffing levels to section chief;

Studies operational problems such as office space utilization, equipment utilization, management reporting systems, staffing patterns, process efficiency, and prepares written recommendations for changes and/or

improvements; Develops project plans to achieve established objectives and time schedules; Writes and/or edits manuals for uniform use of new or revised procedures and policies; Required Knowledge, Skills and Abilities: Principles of work measurement and activity analysis. Principles of statistical methods and techniques.

Employ work measurement techniques, I. E. Stopwatch, pre-determined data, and time ladders. Understand and carry out oral and written instruction provided in the English language. Conduct studies and research with minimal supervision. Complete assignments with independent thought and action within the scope of specific assignments. Work cooperatively with other City employees, outside regulatory agencies, and the public. Enter data or information into a terminal, PC, or other keyboard device using various software packages.

Communicate orally with customers, co-workers, and the public in face-to-face one-on-one settings, in group settings, or using a telephone. Produce written documents with clearly organized thoughts using proper English sentence construction, punctuation, and grammar. Exhibit A. 1 Faucet Stem Assembly Exhibit A. 2 Operations Activity Chart of Faucet Stem Assembly Because these “ incriminations” are typically so small that it would be difficult to measure them easily, we usually combine several smaller work tasks into larger activities. For instance, the tasks “ get washer” and “ insert washer” might be combined.

This leads to the following set of work activities: 1. 2. 3. 4. 5. 6. Get housing and stem. Screw in stem. Get and insert washer. Get and insert screw.

Tighten screw. Place completed assembly in tray. To determine the sample size needed for a time study, suppose we desire a 90 percent probability that the value of the sample mean provides a sampling error of . 01 minute or less. Further assume that is estimated from historical experience to be . 019. Therefore, . 10, z. 05 1. 645, and E . 01 . Using Equation (A. 3), we compute n 9. 8 10 observations A sample size of 10 or more will provide the required precision. Fractional values of n should always be rounded upward to ensure that the precision is at least as good as desired. A spreadsheet that can be used for a typical time study when continuous timing is used is shown in Exhibit A. 3. Continuous timing involves starting the clock at the beginning of each task and recording the cumulative time at the completion of each work task. The task times are found by subtracting successive cumulative times. These are added and averaged to obtain the mean time for each work task. Performance ratings are given in the next-to-last column.

By multiplying the performance-rating factor by the average observed time, we obtain the normal time for each work task and add them. Next the allowances are determined to compute he standard time. For the faucet-stem assembly, we assume a 5 percent personal allowance, 5 percent fatigue allowance, and 10 percent delay of materials allowance. Therefore, the total allowance factor is 20 percent. The standard time for the faucet assembly Job is then computed, using Equation (A. 2), as: Standard time (0. 550)(1 . 2) 0. 660 minutes per faucet assembly.

Thus, an assembler of faucet-stem assemblies can be expected to produce at a standard rate of 1/0. 660 parts per minute, or about 91 parts per hour. In a 7-hour workday with 1 hour off for lunch and breaks, an assembler can

produce 637 acute-stem assemblies per workday. Using Regression Analysis to Determine Standard Time Regression analysis provides an alternative method to estimating the time required to do a particular Job or work activity. Regression analysis is used to predict times based on different attributes of the work, rather than by adding up individual task times.

Using regression to estimate standard times can be advantageous because it avoids the assumption of additive task times when this might not hold; statistically significant variables can be determined; confidence intervals for the prediction can e developed; and finally, it may cost less than a detailed work study. Consider the following problem on developing standard time estimates for installing electrical power lines. An electric power company wishes to determine a standard time- estimating formula for installing power lines. A good formula would help it plan capacity and staffing needs.

The following data are collected: Total Time (hours) 8. 0 14. 0 17. 5 7. 0 16. 0 37. 5 39. 5 10. 5 17. 0 23. 5 16. 5 22. 0 8. 5 28. 5 Number of Poles 12312441232314 Wire (100 feet) 41062. 510243338121218512 No. Of Cross Arms 12324872462328 No. Of Insulators 46361211481246312 No. Of Guy wires 10100212101000 Exhibit A. 4 shows the results using Excels Regression tool. The model obtained from this analysts Time 0. 237 2. 804 poles 0. 514 Wire 0. 170 Insulators 1. 50 Guy wires 1. 09 Cross arms The regression analysis shows a high RE value, showing a strong fit to the data.

Moreover, the p values for the regression coefficients are significant, meaning that each of the variables contributes to predicting time. If the utility faces a situation in insulators, and no guy wires, the predicted time for

the Job would be Time 0. 237 2. 804 4 0. 514 1. 500792 hours 1500 1. 9 7 0. 170 12 Predetermined Time Standard Methods Predetermined time standards describe the amount of time necessary to accomplish specific movements (called incriminations), such as moving a human hand a certain distance or lifting a I-pound part. These small time estimates have been documented and are available in books and electronic tables.

If a Job, work activity, or task can be broken down into such elemental tasks, an estimate of the normal time is made by adding up these predetermined times. This approach is especially appealing for developing standard times for new manufactured goods and some Irvine tasks. An Exhibit A. 4 Results of Regression Analysis for Electric Power Line Installation electronics manufacturer, for example, may have much experience with assembling small electronic components using human labor and keep a record of past incrimination and normal time analyses.

For similar new tasks and electronic component parts, predetermined time standards can be used to estimate new normal times. Predetermined time standards were originally developed for labor- intensive human tasks but data sets exist for machine micrometeorite, such as those involving an automated drill press. Predetermined time standards are advantageous since they cost less than a stopwatch time study, avoid needing multiple performance ratings, and are best for new goods and services. However, this type of incrimination-based time standard is not Justified for small order sizes or infrequent production runs.

In addition, once the new good or service and its associated process are stable and running well, stopwatch or work-sampling time studies still need to be done. Finally, the assumption of additive is sometimes questionable, since a process or assembly sequence of difficult versus simple corrections may or may not be additive. The Debate Over Work Standards Work standards evolved at the turn of the twentieth century, and although they have supported significant gains in productivity, they have been the subjects of debate since the quality revolution began in the United States.

Critics such as W. Edwards Deeming have condemned work standards on the basis that they destroy intrinsic motivation in Jobs and rob workers of the creativity necessary for continuous improvement. That is certainly true when managers dictate standards in an effort to meet numerical goals set up by their superiors. However, the real culprit in that case is not the standards themselves, but managerial style. The old style of managing reflects Tailor’s philosophy: Managers and engineers think, and workers do what they are told.

A total quality approach suggests that empowered workers can manage their own processes with help from managers and professional staff. Experience at Gem’s MINIMUM plant has shown that work standards can have very positive results when they are not imposed by dictum, but designed by the workers themselves in a continuous effort to improve productivity, quality, and skills. 3 At the GM-Fremont plant, industrial engineers performed all of the methods analysis and work-measurement activities, designing Jobs as they saw fit.

When the industrial engineers were performing motion studies, workers would naturally slow down and make the work look harder. At MINIMUM, team members learned techniques of work analysis and improvement, then timed one another with stopwatches, looking for the safest, most efficient way to do each task at a sustainable pace. They picked the best performance, broke it down to its fundamental elements, and then explored ways to improve the task. The team compared the analyses with those from other shifts at the same workstation, and wrote detailed specifications that became the work standards.

Results were excellent. From a total quality perspective, this was simply an approach to reduce variability. In addition, safety and quality improved, Job rotation became more effective, and flexibility increased. Work Sampling Work sampling is a method of randomly observing work over a period of time to obtain a distribution of the activities that an individual or a group of employees perform. Work sampling is a method of randomly observing work over a period of mime to obtain a distribution of the activities that an individual or a group of employees perform.