ENHANCING RELIABILITY OF PROJECT DURATION FORECAST

V. NANDAKUMAR

ENHANCING RELIABILITY

OF

PROJECT DURATION FORECAST

BY

© V.NANDAKUMAR, B.E (HONS)

A Thesis submitted in partial fulfillment of the requirement for the degree of Master of Engineering

Faculty of Engineering and Applied Sciences

Memorial University of Newfoundland

Nov, 1984

St.John's Newfoundland CANADA

ABSTRACT

Reliability of Project duration forecast depends mainly on the accuracy of the activity duration estimates. During project implementation, many uncertain but predictable variables dynamically affect the activity duration. Currently, this impact is considered intuitively,the effectiveness of which depends on the skill of the scheduling engineer. This research identifies the need for a model which can simulate the project environment to incorporate the combined impact of the uncertainty variables in the activity duration estimates.

Significant uncertainty variables are discussed along with random sampling procedures for quantifing their impact. A computer model "PRODUF" simulates and incorporates the combined impact in activity duration estimates. PRODUF computes a distribution of duration estimates for each activity. Monte Carlo simulation on such distributions gives a probability distribution for the tactical plan completion time. This is used at every progress review to develop project duration forecast from the strategic plan.

The PRODUF model has many applications. It can be used to generate forecast of project duration with associated probability. It can be used to determine the criticality index of an activity. The sensitivity of the activities to an uncertainty variable can be measured. As an extension of PRODUF,an improvised gaming model in project scheduling can be developed. Application of PRODUF to a hydro project highlights its practicality.

ACKNOWLEDGEMENTS

I take this opportunity to convey my sincere gratitude to Professor H.N.Ahuja, Faculty of Engineering and applied sciences, Memorial university for his valuable guidance throughout my Master's programme. His inspiring attitude played a major role in successfully completing my Master's thesis. I am grateful to Memorial University, Newfoundland for providing necessary financial assistance during the study period. My thanks are due to Dean Aldrich, School of Graduate Studies for his keen interest and encouragement. I am grateful to Dean Ross Peters and Associate Dean Dr.T.R.Chari of Faculty of engineering for their valuable help in completing all my requirements for Master's programme. I am indebted to M/s Metallurgical and Engineering Consultants(India) Ltd. (MECON), India for granting the necessary study leave. I acknowledge with thanks the permission accorded by Mc Graw Hill book company, the American Society of Civil Engineers (ASCE) and the American Association of Cost Engineers (AACE) for use of their materials. My thanks are due to many of my colleagues and friends who have made my stay very comfortable and enjoyable.

Above all, my wife Vimala and my sons Vignesh and Vivek deserve my appreciation for their remarkable tolerance of my absence from home for a period of 2 years.

Table of Contents

List of Figures

List of Tables

Chapter 1

PROBLEM DEFINITION

1.1 INTRODUCTION

A reliable forecast of project completion date and prevention of delays are major concerns of any project manager. This is so because overhead, interest and escalation costs incurred during the project delay period on off-schedule projects, more often than not, result in cost overrun.

It is known that reliability of a project duration forecast depends on the accuracy of network logic, dependability of individual activity duration estimate and inclusion of the impact of the various uncertainty variables in the project environment such as weather, productivity level etc on the duration estimates. During project implementation, many uncertain but predictable variables dynamically affect the activity duration. Currently, to forecast project duration, their impact is estimated intuitively, the effectiveness of which depends upon the skill of the estimator. Further, a problem arises in quantifying the combined impact of the uncertainty variables. For more reliable forecast of project duration, a computer model is needed [6] which can simulate the expected occurrence of the uncertainty variables based on historical records. It can then explicitly analyse and quantify their combined impact, and incorporate it in the activity duration estimates. Instead of a single value, the simulation can give a distribution of the duration estimates for each activity. Such activity duration distributions are useful in making a reliable estimate of the expected delay or advancement of the project. They can also be used to forecast project completion time and to evaluate the probability of achieving the original schedule. Such a model should be able to generate additional management information such as a criticality index for each activity, point out the need for a schedule revision, and compute the level of sensitivity of an activity to an uncertainty variable. All this is expected to give management an insight into the project schedule so it can take appropriate timely corrective action to keep the project on schedule. Having introduced the problem, this chapter will elaborate it under the following headings:

1. Need for a realistic forecast of project completion time
2. State of the art
3. Project environment
4. Uncertainty variables and their dynamic nature
5. Combined impact of the uncertainty variables
6. Objectives and scope of the research

7: Problem statement

1.2 NEED FOR A REALISTIC FORECAST OF PROJECT COMPLETION

At the planning stage, the project schedule forecasts the project completion time. As the project progresses, progress is evaluated to make a revised forecast. A reliable forecast of project completion time is essential for the following reasons:

1. Sensitivity analysis shows [3] that project schedule is the most critical cost parameter.

2. Many studies [7] have revealed that it is possible to make a relatively greater percentage of recovery if the potential delay is recognized early in the life of a project. The potential recovery decreases as one proceeds through the project until a time is reached when it is no longer possible. The early indication of a delay through a reliable forecast allows decisions to be made in a less hectic environment.

3. A delay in project completion time can cause a cost escalation which will not be less than the inflation, overhead and additional interest cost for the period. A realistic forecast gives a clear picture allowing alternative decisions involving time/cost trade offs to be made.

4. Many contracts have liquidated damage clause relating to delays in project execution. A realistic forecast of delay provides an early warning of exposure to such liquidated damages.

5. Slippage in the field schedule may cause the work to be done after a new labor settlement of wages, always at a higher cost in light of current market and labor conditions. Some work may be pushed from good to bad weather with a tremendous loss of efficiency. It means higher cost to the contractor, an unhappy client, loss of revenue and a bad reputation. All this can be prevented by a reliable forecast.

6. In a production oriented project, the

marketability of the product gets affected if it arrives the market late due to project delays [28]. Any delay in projects relating to infrastructure facilities upsets the economic feasibility of projects that depend on such facilities. An awareness of the current project status along with reliable forecasts helps keep the project on schedule.

7. Many problems that cause project delays are often realised only after the project is complete - a hindsight phenomenon. A realistic forecast can warn about such problems even before they arise and either prevent them or reduce their intensity - forewarned is forearmed.

1.3 STATE OF THE ART

A project can be described as an input - output model. Time, Money and resources are the inputs. It results in output such as buildings, industrial plant etc. A project cycle aids in this transformation. The project cycle comprises of planning and scheduling, implementation, progress evaluation and updating and corrective action and plan modification as shown in Figure 1-1.

1.3.1 PROJECT PLANNING AND SCHEDULING

The project planning and scheduling is concerned with the devolopment of a scheme of action for the tasks comprising the project. The purpose of planning is to ensure that the project can progress towards its end objective. In fact, most of the troubles that confront the project management are traceable directly to faulty planning. While it is impossible to detail the activities of the entire project at the time the project is initiated,

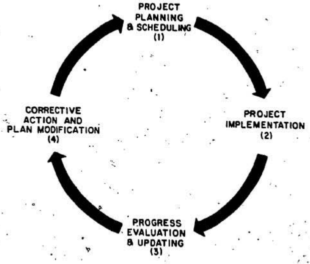


Figure 1-1: Project cycle

projects are generally planned at two levels : strategic plan for the entire duration of the project and tactical plan for 3-4 reporting periods. A reporting period is normally a month, but can vary depending on the information needs of the manager. The strategic plan outlines the major activities of the project in the form of Critical Path Method (CPM) network. The tactical plan is also a CPM network, developed on a recurring basis, but consists of detailed activities of the project for the current and three/four subsequent reporting periods. Normally a contingency time allowance for unforeseen circumstances is made as a fictitious activity at the end of the strategic plan. This allowance represents the number of days of "slip" that can occur before the project becomes late [26]. At this point, it is worth reviewing the current procedure of estimating activity duration.

1.3.1.1 Activity Duration Estimate

The duration of an activity is estimated using the work content of the activity, average productivity and resources used. It is a prediction based on the current information available. The accuracy of the estimate is dependant on the reliability of the historical data. As a general rule, duration estimates should be provided only by those responsible for implementing the activity. At the tactical plan level, construction activities are generally assigned deterministic duration after intuitively incorporating the combined impact of the uncertainty variables. In the Program Evaluation and Review Techinique (PERT) three duration estimates : optimistic, pessimistic and most likely are provided for each activity. These are based on experience from similar projects, either drawn from the memory of the estimator or from the historical data. In both the cases the estimates are subjective. These estimates are also based on the opinions from a group of individuals knowledgeable in the activities to be performed.

Being subjective, the duration estimates are prone to all vagaries of human nature. For instance, one could expect that time estimates made by individuals would depend upon their basic optimistic/pessimistic nature, current moods and costs to them for making inaccurate estimates.

1.3.1.2 Scheduling

During the planning stage, resource availability and other similar constraints are not considered. It is at the scheduling stage that consideration is given to these constraints. Schedules form the measure against which the progress is evaluated and serves as the basis for forecasting project completion time.

1.3.2 PROJECT IMPLEMENTATION

Once the project planning and scheduling is complete, the project implementation starts in accordance with the schedule. During implementation, the uncertainty variables cause a deviation from the original plan. In most cases, the deviation will normally be an increase in the duration planned for an activity. This has to be identified as early as possible to avoid project delay and or cost overrun.

1.3.3 PROGRESS EVALUATION AND UPDATING

During project implementation, progress is monitored and feedback is used to update the plan. Project feedback becomes available only after the project has been in progress for sometime. Progress evaluation involves progress data collection and reporting and use of the feedback for updating purposes. During progress evaluation, the schedule status is reviewed and unfinished activities are rescheduled using the current project status. Updating requires computer processing via a typical network analysis computer program, the input-output from which is illustrated in Figure 1-2.

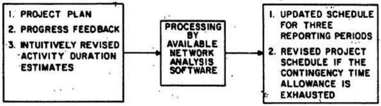


Figure 1-2: Input-Output from a computer program used for updating

It is clear from the figure that the currently available updating procedures do not incorporate explicitly the combined impact of the uncertainty variables.

During progress evaluation, management evaluates actual against planned progress, identifies causes of delays in view of the experience gained, and revises activity duration estimates. Different methods of progress reporting and the corresponding updating procedures are in use. A brief explanation of the different available methods follows.

1.3.3.1 Forecasting Project Duration Based On Original Schedule

In this method, the revised project completion time is forecasted on the assumption that the activities thereafter will proceed as per the original scheduled duration. Therefore, the time required to complete the remaining activities is calculated using the original schedule. It is then added with the elapsed time as shown in Figure 1-3.

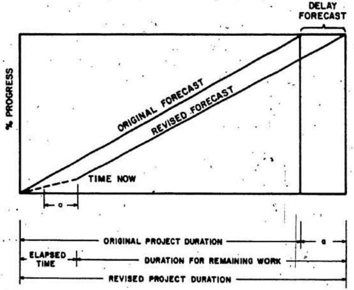


Figure 1-3: Forecast of project duration based on original schedule

It shows that from "time now" onwards, the project will follow the original schedule. The projected delay "a" at the end is equal to the delay "a" experienced to date.

This method has two limitations. First, it does not consider, for future predictions, the trend of the performance accomplished on the project activities. Second, there is no provision to accommodate the effect of the uncertainty variables.

1.3.3.2 Forecasting Project Duration Based On Past Performance

In this method, the duration to complete the remaining work is forecasted by extrapolating from the progress accomplished in the past. The extrapolated duration, when added to the elapsed time, gives the total project duration as shown in Figure 1-4. The major limitation of this approach is the anticipation (rightly or wrongly) that the remaining work will follow the trend established so far.

1.3.3.3 Forecasting Project Duration Based On Current Status

In this method, neither the original estimate nor the extrapolated duration is considered as the sole basis for forecasting. The completed activities have actual durations. The estimates of duration for the activities not started and the activities in progress are revised by intuitively considering the impact of the various uncertainty variables. This method, as shown in Figure 1-5, is currently widely adopted for progress evaluation and is

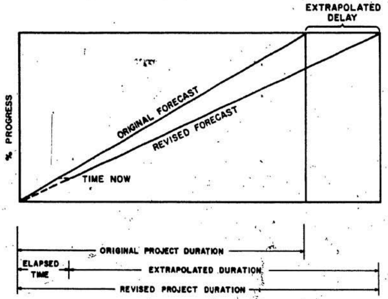


Figure 1-4: Forecast of project duration based on past performance

more reliable compared to the preceding methods. The only limitation is the subjectivity in incorporating the impact of the uncertainty variables in the activity duration estimates.

1.3.4 CORRECTIVE ACTION AND PLAN MODIFICATION

As already stated, corrective action to bring the project on schedule is specified in order to offset the impact of the uncertainty variables. At every progress review, this impact is considered, although intuitively.

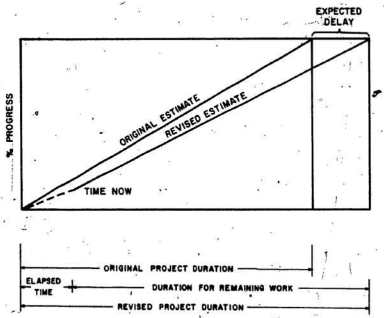


Figure 1-5: Forecast of project duration based on current status

Thus the reliability of the activity duration estimates, project completion time forecast and the effectiveness of the corrective measures, all depend on the adequate incorporation of the combined impact of the uncertainty variables.

Modification to the strategic plan occurs when it is forecasted that the contingency time allowance is exhausted. The project cycle is repeated until the project is complete.

From the preceding discussion of the project cycle vis-a-vis the forecast of project completion time, it is clear that no analysis or simulation technique is used to incorporate the combined impact of the significant uncertainty variables. Thus, project management is unable to reliably anticipate the potential schedule delays.

1.4 PROJECT ENVIRONMENT

A review of the project environment will bring the project uncertainties into focus. Owners, contractors and consultants on many large and medium size projects, use network planning for forecasting project duration. During planning, certain environmental conditions such as weather, labor availability, soil conditions etc. are assumed depending upon project location and date of performing the activity. These estimates would hold if the project environment assumed during planning was to remain static during the entire implementation period. But in real life, the project environment, comprising many uncertainties, is dynamic and affects activity duration. Uncertainties are classified as predictable and unpredictable. Predictable uncertainties are those in which past information will permit a quantitative assessment of the risk involved. Past behaviour can give a basis for assisting in predicting future behaviour but statistical extrapolations are sometimes misleading and dangerous. The best examples of the predicable uncertainty variables are weather, space congestion, crew absenteeism, learning curve effect etc. The unpredictable uncertainties include wild cat labor strikes, war, contract litigations etc.

Project delays can be identified and accommodated to the extent that one is able to detect and quantify the uncertainties. The assessment of their impact is a complex problem because the variables are non mutually exclusive and are not statistically independent. For example, an activity like pouring concrete is more sensitive to weather than an activity like interior painting or indoor equipment erection. Again, the impact of weather on pouring concrete will vary depending on the time of year. Due to the impact of many such uncertainty variables, the activity durations will deviate from the original estimate. This may result in making another set of activities critical. Most current project scheduling and updating systems give a deterministic project completion time and have no provision to simulate the project environment to evaluate the expected impact of uncertainties on activity durations. If the project schedule is to be met, there must be a reliable method for detecting and remedying the causes of delay.

1.5 UNCERTAINTY VARIABLES AFFECTING ACTIVITY DURATION ESTIMATES

Some of the uncertainty variables that cause deviation in activity duration estimates are:

1. Learning curve
2. Weather
3. Space congestion
4. Crew absenteeism
5. Regulatory requirements
6. Design changes and rework
7. Foundation conditions
8. Design data collection
9. Drawing approval schedule
10. Inspection schedule
11. Ineffective supervision
12. Inefficient consultant

13. Economic activity level
14. Labour unrest
15. Crew interfacing
16. Project complexity
17. Building code
18. Transportation schedule
19. Legal problems
20. Union problems, etc
21. Construction materials delivery schedule

Three observations can be made : First, only a few of the preceding variables affect all activities. Second, even this long list is not exhaustive and activities may be affected by yet other variables. Third, some variables may have a more significant impact than others.

The selection of significant variables should be based on the following considerations:

1. Effect on most activities from the project's concept to commissioning stage.

2. Uncertainty variables shown by research to have significant impact.

It is known that the average productivity, the basis for the activity duration estimate, assumes a certain learning curve effect. As the project progresses, deviations such as activity interruptions, ineffective supervision, experienced crew leaving the site etc. continuously cause variation in the learning curve effect [23] resulting in increased activity duration.

Baldwin and Mantres in their paper "Causes of Delay in Construction Industry" state [24] that their survey conducted among engineers, architects and contractors ranked weather as the topmost uncertainty variable. According to Neal, 50 percent of the construction activities are affected by weather [21].

The U.S.Dept. of Labor identified [9] space congestion as an important topic for further research. Borcherding states [10] that about five manhours per craftsmen per week are lost due to space congestion and overcrowded work areas.

The preceding study also revealed that crew absenteeism is a major menace in the construction industry and, on an average workforce, the range of daily absenteeism varies between 3 to 10 percent. Absenteeism has been observed to be as high as 50 percent on cold and rainy days.

Suhanic in his paper "Change Orders Impact on Construction Schedule" states [8] that design changes and the subsequent rework account for 20 percent delay on a project. Borcherding quotes result of a survey [10] in which 59 percent of the tradesmen surveyed viewed rework activities as a hindrance to the job progress. The task force to study the causes of two years delay in Trans Canada pipelines lays the blame [4] primarily on the various regulatory procedures involved.

Similarly the economic activity prevailing at the project locale affects the productivity resulting in an impact on duration. If the activity level is high, the demand for labor increases resulting in the increasing employment of marginally qualified craftsmen. Due to the increase in the number of projects, many job openings become available resulting in the increased turnover. All these situations cause a disruptive, inefficient situation resulting in lower productivity and extended activity duration.

Labor unrest, many times, becomes significant during certain periods of project implementation. During the past, many projects have come to a standstill for days or months due to labor strikes. It is possible to anticipate the impact on productivity if any wage contract negotiations are due during the tactical plan period.

In addition, certain activities may have a specific uncertainty variable capable of causing delay. It is therefore necessary to keep provision for accommodating one specific uncertainty variable.

Based on the preceding discussions, a few uncertainty variables, which significantly affect most of the activities from the beginning to the end of a project, are selected as significant uncertainty variables, as shown in Figure 1-6. These are :

1. Learning curve
2. Weather
3. Space Congestion
4. Crew absenteeism
5. Regulatory requrements
6. Design changes and Rework
7. Economic activity level.
8. Labor unrest
9. Specific uncertainty variable

1.6 CLASSIFICATION OF THE UNCERTAINTY VARIABLES

The various uncertainty variables that affect activity duration estimates, can be classified into two groups:

1. Variables the influence of which depends on the project calendar date when the activity is performed. Weather, crew absenteeism, economic conditions etc. are such variables. These will be called : time dependent variables.

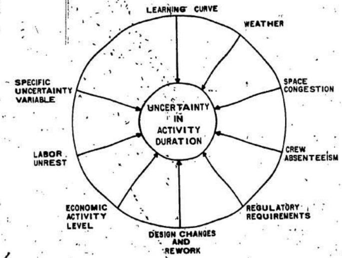


Figure 1-6: Significant uncertainty variables

2. Variables that affect productivity regardless of the time of the year when work is performed. Learning curve effect, space congestion, design changes and rework etc., are some of the examples. These will be called independent variables.

1.7 DYNAMIC NATURE OF THE INFLUENCE OF THE UNCERTAINTY VARIABLES

The impact of the uncertainty variables on the duration estimate of an activity is dynamic and depends on the project environment for the activity. For example, consider the influence of weather. It has more influence on "excavation" than on equipment erection inside an enclosure. Again, the delay in the excavation activity due to the time dependent variable, weather, will vary depending on the calendar date when excavation is actually carried out. Similarly the original schedule may not have any delay due to space congestion, but as the project progresses, certain activities get shifted and cause space congestion resulting in delays. Further, if the project gets delayed and moves into a period of high economic activity, lower productivity results. All this shows the dynamic nature of the uncertainty variables and indicates that there is possibly a significant correlation among the uncertainty variables.

1.8 COMBINED IMPACT OF THE UNCERTAINTY VARIABLES

The present planning, scheduling and updating methods consider the impact of the uncertainty variables only intuitively and do not simulate the project environment to combine their impact in reestimating activity durations. Further, there is no means available to measure the likelihood of an activity becoming critical due to the influence of the uncertainty variables. Also if the sensitivity of an activity to different uncertainty variables is known, the management can possibly give required attention to it.

From the literature survey, it is observed that Baldwin, Mantres, Gates, Scarpa, Parviz, O'Shea and Suhanic have made studies [8, 9, 18, 23, 24, 25] on the influence of individual uncertainty variables. Halpin and Woodhead have developed [18] project management games incorporating the influence of a few uncertainty variables on subjective basis. Recently, researchers have extended [13, 17] the gaming model to make a reliable forecast of project completion time. The following deficiencies are observed:

1. Although some models consider the individual impact of some of the uncertainty variables over activity duration, only a start has been made to combine their impact. Methods accounting for the combined impact of significant uncertainty variables from simulated project environment to give management additional insight into activity and project duration distribution are not available.

2. Not many forecasting models distinguish between strategic and tactical plans. It makes sense to treat them separately because changes in the project environment can be predicted with greater confidence for the shorter tactical plan period while simulating project environment.

3. Two types of progress reports are required separately for the executive level and top level management respectively. Currently, project updating procedures stop at project schedules suitable to executive level management. The top level management needs project schedules which consider the combined impact of the uncertainty variables. The reliability of management reports generated based on PERT estimates is questionable since these estimates are subjective in nature. Reports based on simulation of the impact of the uncertainty variables will certainty be more reliable. A model that can generate progress reports both for the executive and top level management does not exist. Such a model will be useful since the adoption of any new model in the construction industry depends on its capability to enhance reliability of information for management use with least disturbance to the existing procedures.

These deficiencies pinpoint the problem and can be restated to define the objectives and the scope of the research.

1.9 OBJECTIVES OF THE RESEARCH

1. To define the various significant uncertainty variables, and to devise a suitable method of simulating their impact on the activity duration estimates.

2. To determine through simulation, at each progress review, the combined impact of all uncertainty variables, incorporate it in the duration estimates of tactical plan activities and obtain the expected activity duration distribution.

3. To determine from simulation the tactical plan completion time distribution.

4. To determine from simulation the alternate project completion time distribution using the strategic plan.

5. To predict the probability of meeting a schedule deadline from the distribution of project completion time.

6. To determine the criticality index for the tactical plan activities and also evaluate their sensitivity to the specific uncertainty variable that causes major delay in their completion.

7. To independently perform the preceding analysis using the available progress data and also without disturbing the existing updating procedures.

8. To investigate the other applications of the model.

1.10 SCOPE OF WORK

1. The proposed research will consider the combined impact of a set of selected significant uncertainty variables. In addition, provision will be kept to include one more uncertainty variable, considered significant to an activity.
2. Since it is not possible to select a set of uncertainty variables significant to all projects, the significant variables selected for this research must be replaceable.
3. Since it is impracticable to predict with any degree of confidence the impact of the uncertainty variables for a timespan longer than four reporting periods, the model will consider the impact for the tactical plan only.

1.11 PROBLEM STATEMENT

The project environment considered while estimating an activity duration at the planning stage does not remain static during its implementation. The intuitive consideration of the combined impact of the uncertainty variables many times fail to produce reliable project duration forecasts. Management requires a probability distribution associated with the forecast for the tactical and the strategic plan completion time . For the purpose, the expected variation in the activity duration estimate due to the influence of the project environment is to be found out.

The present scheduling and updating procedures do not perform any explicit analysis to generate such information. There is a need for a computer model which can simulate the project environment to incorporate the combined impact of the uncertainty variables in activity duration estimates to generate more reliable project duration forecasts at each progress review. Such a model can generate additional management information such as criticality index for each activity and its sensitivity to an uncertainty variable.

Chapter 2

UNCERTAINTY VARIABLES - DEFINITION AND QUANTIFICATION OF IMPACT

Having defined the problem, the uncertainty variables can be discussed to describe a methodology for simulating their impact on activity duration estimates. This chapter describes in detail the significant uncertainty variables selected in the preceding chapter and delineates suitable simulation methods to quantify their expected impact.

2.1 LEARNING CURVE

The basic principle of the learning curve [17, 23] is that the skill and productivity in performing tasks improves with experience and practice. The use of subcontracting is a recognition of this fact. One such curve, a plot of proficiency against practice is shown in Figure 2-1. The famous Wright's law states [15] that the cumulative average time (CAT) required to perform a complex task varies exponentially and inversely as the number of repetitions increases geometrically. This phenomenon applies to individuals as well as to a team of workers forming an integrated crew.

Normally the decrease in the cumulative average time

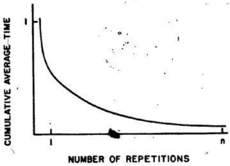


Figure 2-1: Proficiency against practice

depends on the decremental constant for the construction activity each of which has its own value. Suppose an activity "clear site" involves clearing 4 acres of land over a duration of 3 days i.e a CAT of 0.75 day/acre. Obviously, each acre of land will not be cleared in 0.75 day. The time required follows a pattern of decreasing value, with increase in repetition of work, according to learning curve effect. The decremental constant is 0.866 implying that the average time required for the second acre will be 0.866 times the time required for the first. Considering geometric progression, it will be observed that CAT required for clearing 4 acres will be (0.866x0.866) = 0.75 day/acre. If an 8 acre site was to be cleared, the CAT will be 0.65 day/acre (0.866x0.866x0.866).

Learning curve impact is a subject of several published studies. One study carried out by the U.S. Department of Labor [23] has compiled a table of the training period required for an apprentice to achieve journeyman status for different categories of work. This information is useful when new apprentices are recruited or when an apprentice joins in the middle of the project as a replacement.

A United Nations publication shows [23] that the cumulative average construction manhours per storey as a ratio of the first storey decrease as the number of repetitions increases. Figure 2-2 is reproduced from the study. Gates et al [19] have reported separate decremental constant for building structures, individual construction elements requiring many operations to complete, construction elements with few operations to complete and building elements manufactured in plants. According to authors, certain subjective analysis of the learning curve effect are :

1. Individual type of operations will exhibit a greater rate of routine acquiring than crew type operations. Same may be said of operations performed with small crews compared with operations requiring large crews.

2. Less skilled a trade is, the greater is the initial efficiency of the trainee in terms of productivity as a percentage of normal prior to training.

3. Working overtime or increasing the number of crews result in an apparent loss of potential increase on account of experience curve effect.

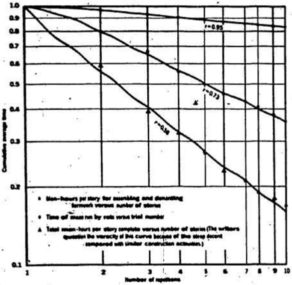


Figure 2-2: Three experience curves

While estimating activity duration for a project, the tendency seems to take average productivity from similar activities on several projects. Many deviations take place in real life situations during the progress of a project such as:

1. The competence of the presently available crews may be different from that envisaged at the planning stage. This aspect gives a variation in

decremental constant due to which the cumulative average time increases.

2. Work is sometimes stopped temporarily on a particular operation and resumed later. Researchers in psychology and industrial engineers find (19) that the learning curves are adversely affected by these interruptions. In other words, a substantial part of the routine acquiring proficiency is lost. A complicated situation arises when the interruption or delay culminates in a change necessitating a new procedure or an altered composition of the crew or new members of the crew.

3. Supervisory personnel's ability and the subcontractor's competence may be different than envisaged.

4. Some experienced crew may quit the site abruptly necessitating recruiting a new crew thereby losing the learning curve effect.

5. If any change orders are issued , learning curve gains may be lost due to discontinuity or rework.

These deviations affect the decremental constant resulting in a change in CAT and hence affect the activity duration estimate. This can be explained with an example. Consider an activity for erection of 200 tonnes of mechanical equipment. It is determined from similar projects that the erection requires a CAT of 4 hours/tonne. In practice suppose it takes 7 hours to erect the first one tonne. The time required for erecting the remaining tonnage will be less as workers become familiar with each other and get used to erection technique and area of working. The CAT of "4 hours" would have held if the conditions and environment assumed during planning were static. Deviations as described earlier cause changes to the pattern of the curve resulting in a revised CAT.

When an activity is interrupted for a period of time and continued again, a certain amount of delearning takes place resulting in increased activity duration. Gates interprets the impact due to interruption as shown in Figure 2-3.

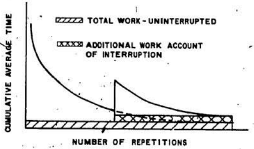


Figure 2-3: Impact due to interruption

The formula for calculating the increase in CAT due to interruption and the subsequent delearning effect(19) follows:

$$CAT_r = CAT_i + \left[1 - \frac{1}{log\,(d+10)}\right] \times (1 - CAT_i)$$

Where

CAT_r = cumulative average time (revised)

CAT_i = Cumulative average time (initial)

d = period of interruption

As already explained, the activity duration estimate is derived from the CAT for the activity, a variable dependent on the decremental constant which itself is a variable. The factors that cause this variation are random in nature resulting in similar variation of the decremental constant. Depending on the type of activity and project environment, a range of values for the decremental constant can be estimated.

2.1.1 IMPACT OF LEARNING CURVE

The learning curve impact, as illustrated in Figure 2-4, is simulated by random sampling from the range of decremental constant. The initial decremental constant is computed from the initial CAT determined using the given duration and the volume of work etc. Using historical data for the variation in the decremental constant, revised value of the decremental constant is simulated and the corresponding activity duration is determined. This revised activity duration replaces the original activity duration estimate and forms the basis for further computations.

2.2 INCLEMENT WEATHER

Weather is one of the most difficult and unknown variables that influences construction projects. Baldwin et al. in their paper on "Causes of Delay in Construction" state [24] that according to contractors, Architects and engineers who responded to their survey, weather as a cause

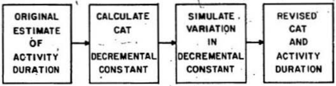


Figure 2-4: Impact due to learning curve

of delay in construction has severity indices of 90, 74, 66 percent respectively. (severity index is defined as the total percentage of respondees giving a particular response). It has a top ranking among the various causes of delay in construction. According to Neal, 50 percent of the construction activities are affected by weather [21].

Weather faced by an activity is dependent upon the time of the year. Therefore, in dealing with weather impact, one must recognise the following (13):

1. Weather affects all concurrent activities that are susceptible to its effect.
2. When an activity is delayed due to weather, the start times of the immediately following activities are shifted thereby exposing the activities to changed environment.

The impact of weather is considered under two subtopics : i) when productivity is reduced and ii) when work must be interrupted.

i) When Productivity is Reduced .

Weather conditions affect productivity resulting in an extension of activity duration. For example, due to cold weather [26], heavy boots and clothing are required which slows down movement. The frigid weather necessitates frequent stops to warm up and have a cup of coffee.

Another study, "Weather Effect on Mason Productivity "[20] relates the variation in mason productivity to temperature and humidity variations and establishes the relative productivity achieved at different temperature-humidity combinations as a fraction of the optimum considered at 24 degrees C and 6 % humidity. Similar relationship can be derived for crew productivity variation at different weather conditions for activities like excavation, formwork, concreting etc.

The gaming model "Constructo" [14] considers the effect of weather on crew productivity. Constructo reduces productivity in a predetermined manner if the activities are exposed to rain or high temperature.

ii) When Work must be Interrupted

Excavation in frozen ground is done differently and at a different rate than under normal conditions. Specifications completely prohibit asphalt paving during winter and plumbing test cannot be conducted when hard freeze has set in. Also, masonry freezes if continued in severe winter. A rainfall of 1.3 mm per hour is sufficient to stop exterior painting .

2.2.1 IMPACT OF INCLEMENT WEATHER

Before arriving at a basis for considering the impact of weather conditions, it is necessary to review the earlier studies. The paper "CPM on Calendar Day Algorithm "[25] suggests two major concepts to account for weather impact on activity duration. These are Pull date concept and weather adjustment routine concept. In pull date concept the planner generates a project calendar with certain dates removed to account for time lost due to bad weather. The pulled dates are chosen randomly so that the total number pulled in one period equals the number normally lost at that time of the year. The limitations of this approach are :

1. No work, including indoor work that does not depend on weather, progresses on the days pulled out.
2. It creates bias ; some activities may fall between pulled dates and therefore, have no lost time allowance while others may fall in such a way that too much of the lost time allowance is assigned to them.

Weather adjustment routine concept involves the following two factors:

i) Weather factor reflecting seasonal changes

ii) Weather sensitivity factor

The weather factor is a percentage of the available working time in a month that most weather dependent activities are expected to lose due to inclement weather.

Since all activities of the project are not equally susceptible to weather, the weather sensitivity factor reflects the dependence of each activity on weather. It adjusts the weather factor and gives a separate percentage for individual activities. This percentage varies from 0 percent for activities completely independent of weather(indoor finish work) to 100 percent for highly weather dependent activities such as concrete pour. In this approach, the day to day weather parameters are not related to the impact considered. Also, it is difficult to fix the weather adjustment factor for different activities.

A paper on "Causes of Delay in Construction" [24], based on a survey, concluded weather as the top ranking factor causing delay in construction. It emphasizes that past weather data should be geographically compiled and published with special emphasis on the needs of the construction industry.

Specific studies [20] have been made relating mason productivity to the changes in humidity and temperature. Carr in his paper "Simulation of Construction Project Duration " [13] suggests a progress day loss tabulation for different weather conditions against each activity as reproduced in Table 2-1. In table 2-1, temparatures are in °F and rainfall in inches. Further, HI and LO indicate highest and lowest temparatures and RN2, RN3 indicate contihuous rain for 2 days, 3 days etc. The progress day loss is tabulated depending on the weather faced by the activity. For example, "erect tower " (Activity 17) would

PARAMETERS / ACTIVITY DESCRIPTION	HI < 40	< 50	< 60	HI ≥ 90	≥ 100	≥ 10	LO < 10	< 20	< 30	< 40	RN ≥ 0.10	≥ 0.25	RN 2 ≥ 0.25	≥ 0.50	RN 3 ≥ 0.50	RN 7 ≥ 1.00	≥ 3.00	RN 14 ≥ 3.00	≥ 5.00	RN 28 ≥ 8.00
1. PREPARE SHOP DRGS.																				
2. TOWER FOUNDATION EXCAV.	1	.3									.5		1		1	1		1		1
3. SHELTER	1	.3									.5		1		1	1		1		1
4. PROCURE INSTRUMENTS																				
5. FABRICATE TOWER																				
6. FOOTING FORMS		1	.4		.1	.2					.5	1		1			1		1	
7. TIE DOWN EXCAVATION	1	.3									.5		1		1	1		1		1
8. SHELTER FORM		1	.4		.1	.2					.5	1		1			1		1	
9. PLACE FOOTING CONCRETE				1	.3				.1	.3	.5	1		1		1			1	
10. TIE DOWN FORMS		1	.4		.1	.2					.5	1		1			1		1	
11. PLACE CURE CONCRETE									1	.3	.5	1		1		1			1	
12. PIER FORMS		1	.4		.1	.2					.5	1		1			1		1	
13. PLACE CURE CONCRETE							1	.5	.2											
14. ERECT SHELTER		1	.4		.1	.2					.5	1		1			1		1	
15. PLACE CURE PIERS							1	.5	.2											
16. INSTALL INSTRUMENTS																				
17. ERECT TOWER	1	.7	.3		.2	.4					.5			1		1		1		1
18. TEST INSTRUMENTS																				
19. COMPLETE & TEST SYSTEM																				

Table 2-1: Progress day loss tabulation

have no progress on the day when maximum rain for two days exceeds 6 mm. Weather sensitivity from historical records can be tabulated on similar lines for each activity of a project. Even though weather conditions can not be controlled, knowledge about the anticipated weather can assist in offsetting at least a part of its effect.

"MEANS Scheduling Manual", 1981 suggests that a good way is to establish a duration estimate, examine the time of the year the activity will take place and add to the duration estimate appropriate number of days for bad weather.

Generally, 2 days/week is added in the winter, 1 day/week is added in the spring and 1/2 day/week is added in the summer months.

To quantify the expected impact of weather which depends on the nature of work and the calendar date when the work is scheduled, the following historical weather data is collected for the region for each day of the year for a number of years depending on the availability of data and the nature of the project:

Daily maximum temperature.

Rainfall, if any, on each day.

snow fall, if any, on each day.

The expected weather for each day during the tactical plan period is sampled randomly from the data for that day. From a tabulation of the expected workday loss for each activity under different sets of weather conditions, the expected workday loss is calculated for the activities planned on each day. The procedure for simulation of the impact due to inclement weather is shown in Figure 2-5.

2.3 SPACE CONGESTION

Space congestion may result from the physical features of the project or from high density of tradesmen working in an area. Parviz refers [9] to a suggestion from U.S. Department of Labour that one urgent and necessary area of research was that of predicting and minimizing the effects of working space congestion. Work areas can become so

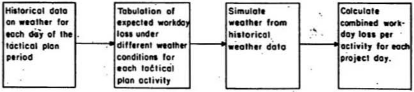


Figure 2-5: Impact due to inclement weather

crowded that craftsmen have difficulty even walking in that area. An example is the later construction stages of reactor containment vessels in nuclear power plants. While estimating durations of activities, no consideration is given to the loss of productivity, if any, resulting from congested space. As the project progresses, activities are delayed or advanced in order to meet the schedule changes. Consequently, activities sometimes interfere with each other because of their concurrent requirements for working space within a confined area. Although the congestion becomes so obvious later, it is the result of failure to stagger activities in time. Parviz [9] gives graphical representation of maximum congestion for each of the work areas of a power plant at different levels. Another study [11] indicates that the overall estimate of lost time as a result of overcrowding/space congestion was around 5 manhours/craftsmen/week.

2.3.1 IMPACT OF SPACE CONGESTION

In order to calculate the workday loss due to space congestion, a common base of comparison must be worked out. For this purpose, the space requirement for each piece of equipment is expressed in equivalent number of men. The total space requirement for each activity, assumed to be uniform throughout its life, is then computed. The project area is divided into separate work zones and the space requirement by zone for each activity is specified. The model considers activities planned on each day and determines any possible space congestion in designated zones. If any congestion is observed, activities with float are delayed. For critical activities, the workday loss due to reduced productivity is calculated. This procedure is shown in the flowchart in Figure 2-6.

Figure 2-6: Impact due to space congestion

2.4 CREW ABSENTEEISM

Crew absenteeism can be a major menace in the construction industry. Depending on crew formation absenteeism of crucial tradesmen may make it necessary even to stop work on an activity. Borcherding in "Productivity of Craftsmen and Foremen"[11] indicates that the daily range of absenteeism varies between 3 to 10 percent of the workforce. Absenteeism is a factor dependent upon the time of the year and weekday under consideration. It has been observed to be as high as 50 percent on cold and rainy days and at an average between 20 to 25 percent during winter. It is also higher at week ending and week beginning days compared to midweek days. Present scheduling techniques do not consider the impact of crew absenteeism while estimating activity duration.

2.4.1 IMPACT OF CREW ABSENTEEISM

Here again, the range of percentage absenteeism for each month separately for midweek and weekend days is taken from the in-house historical data on crew absenteeism. Other inputs are the total manpower required for each month and expected range of workday loss for each activity as a result of crew absence. From the percentage absenteeism and total manpower, the model samples randomly the number of absentees for each workday. Absentees, if any, are distributed randomly on the activities planned for the day and the expected workday loss for activities is simulated as shown in Figure 2-7.

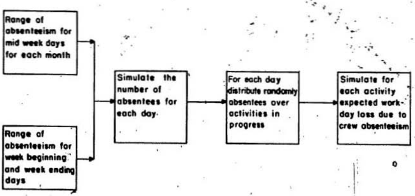


Figure 2-7: Impact due to crew absenteeism

2.5 REGULATORY REQUIREMENTS

Many regulations have negative impact on project progress, especially when they are confusing. Excessive time and money is lost in obtaining the multitude of permits and in preparing time consuming reports and statements. Due to regulations of the Nuclear Regulatory Commission in the United States, more installed work in a nuclear project requires modifications to meet the regulations. The Task Force to study the causes of the two years delay in Trans

Canada Pipeline lays the blame [4] for the delay primarily on the regulatory requirements for time-consuming and often repetitive environmental assessment review. Productivity suffers most by inept and unfair enforcement of regulation by unqualified personnel, given wide authority resulting in increased risk to the project due to the lengthened duration. An example is the extensive requirements encountered in an nuclear power plant for reviewing early plan and design for licencing [16]. Many projects must proceed under the continued threat of shut downs, delays, harrassment and court challenges due to regulatory requirements. Further, regulatory agencies and their regulations are in a constant state of transition. It is observed [14] that it takes an average of 2.5 years to complete the planning review and permit process to build a community of new homes. The project must also conform with additional regulations, new and/or changing rules, and procedures during its construction period resulting in further delays.

It is observed that more and more government regulations are being added :

1. Safety of design and field construction methods.
2. Environmental consequences of project.
3. Personnel policies at all levels.

Scheduling techniques that ignore this impact result in less reliable project duration forecasts.

2.5.1 IMPACT OF REGULATORY REQUIREMENT

Only those activities that are likely to be affected by regulatory requirements need be considered. Due to regulatory requirement two types of productivity losses are possible ; daily workday loss and workdays lost at the end of an activity. At this point it is relevant to explain what is meant by the workday loss expected at the end of an activity. An activity, after it is complete, may be again worked on for a few more days due to some specific reasons such as enforcement of regulatory requirements, design changes etc. The duration of such activities get extended further. The increase in the duration is termed as end of activity workday loss. Based on historical records, a range for both types of workday losses is established for the activities expected to be affected by regulatory requirements. By random sampling, the expected daily workday loss is found for such activities and also workdays expected to be lost at the end of the activity, if any. This is shown in Figure 2-8.

2.6 DESIGN CHANGES AND REWORK

Design changes and rework although inevitable on any project become unavoidable on projects when design, construction and commisioning phases overlap. A majority of rework can be attributed to change orders and ambiguities in design. A few other reasons are:

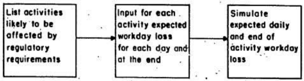


Figure 2-8: Impact due to regulatory requirements

1. Errors and omissions in the original design work.
2. Attempts to incorporate the latest improvements/developments in technology.
3. Changes justified to improve rate of return.

Design changes and rework cause the sequence of work to be disrupted resulting in reduced productivity. Design changes, not only affect the items being designed, but also affect other interrelated work. Their effect is magnified during construction stage when work, materials, equipment etc. may have to be scrapped and activities accelerated to meet the schedule.

Design changes are considered timely and appropriate, if issued in sufficient time to allow for proper planning. When they require the finished work to be held, demolished, removed or modified, they affect the project rhythm. Project rhythm is extremely important and must be maintained if the schedule is to be met. Further if the work flow is disrupted by a change order, conditions such as maneuverability and float availability to the contractor are upset. All this results in reducing the available crew hours for the project, extending its duration. Borcherding in his paper "Major Factors Influencing Craft Productivity" [10] states that the extra hours spent on rework amounts to 6 hours/individual/week. He also quotes results of a survey in which 59 percent tradesmen surveyed viewed rework activities as a hindrance to the job progress. According to Suhanic, many first line supervisors, when asked to explain the reason for low percentage of the total workforce deployed on new construction work, attributed it to the engagement of a substantial part of the workforce on rework [8]. This results in deterioration of motivation. He reports the case history of a project where, out of 260 change orders, 62 change orders were found to have affected "project rhythm". Out of these 62, sixteen change orders were dropped because they were found to be insignificant and were not critical. Out of the balance 46 change orders, four change orders alone were concluded to have lengthened the project schedule by 80 working days which represented about 20 percent of the project duration.

A subjective observation is that change orders have a detrimental effect on morale and efficiency of labor especially if the work has to be scrapped or repeated.

2.6.1 IMPACT OF DESIGN CHANGES AND REWORK

The ideal system to quantify the impact of a change must be a method of computing the variation in duration for every change order which is a difficult task. However, based on historical records and experience, it is possible to categorise activities that are prone to design changes and rework and also specify for them a range of workday loss expected during their implementation. Workday loss, either daily expected loss or total days lost at the end of the activity, can then be simulated, as illustrated in Figure 2-9.

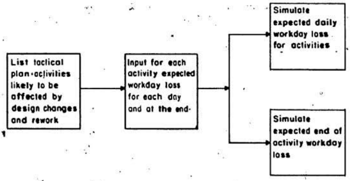


Figure 2-9: Impact due to design changes and rework

2.7 ECONOMIC CONDITIONS

The degree of economic activity existing in an area during construction affects productivity since the demand for labor increases with the volume of construction. Lorenzoni in his paper on "Productivity. . . . . Everybody's Business and it can be Controlled" [12] mentions that there is a twofold impact on labour productivity. First, the project acquires a number of marginally qualified craftsmen and helpers in the process of soaking up all the local labor. These crews when mixed with the average labor, reduce the overall productivity from the levels attained during the times of normal economic activity. Second, the turnover increases dramatically resulting in lower productivity. In addition sometimes, the situation warrants that the labor must be brought in from outside the local area. Experience has shown that in such situation, the overall productivity declines, including the productivity of the local craftsmen.

2.7.1 IMPACT DUE TO ECONOMIC CONDITIONS

The ratio of the number of workers required in an area to the normal number of workers available has a relationship with the productivity as shown by Lorenzoni which is reproduced in Figure 2-10. It shows how productivity gets reduced with the increase in the ratio of the number of workers required in an area to normal number of workers

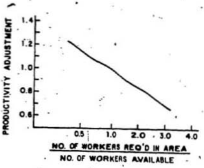


Figure 2-10: Productivity vs workers requirement/availability

available. This relationship is used to quantify the impact due to economic conditions. The ratio is determined for the tactical plan period on a monthly basis. The corresponding productivity adjustment factor is read from the equation. This value is used for calculating the workday loss or gain expected for all activities planned during that period. The procedure is illustrated in Figure 2-11.

2.8 LABOR UNREST

Labor unrest, often, causes the project progress to halt. The days lost to a strike must be added to the project duration. However, when a project is not picketted and the entire project is not shutdown, the expected productivity loss due to labor unrest can be estimated.

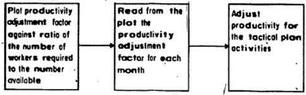


Figure 2-11: Impact due to economic activity level

Labor unrest has many reasons ; symptomatic among them are current contract expiry, wildcat strikes which occur due to accident, management attitude, disciplinary action, overtime problems etc. An environment of labor unrest bodes downturn in productivity varying with the type of activity, unions etc. As is true for other uncertainty variables, the impact of labor unrest can at best be predicted for the short range of the tactical plan.

2.8.1 IMPACT DUE TO LABOR UNREST

A historical range of productivity loss can be associated with labor problems separately for the various unions. For activities likely to be affected, this loss can be sampled randomly. Figure 2-12 shows this procedure.

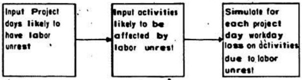


Figure 2-12: Impact due to labor unrest

2.9 SPECIFIC UNCERTAINTY VARIABLE

In addition to the preceding variables, certain activities may have yet another specific uncertainty variable capable of causing delay. For example, failure of drilling equipment may cause a major delay in a Drill Well activity. It is useful to identify such specific uncertainty variable, if any, for each tactical plan activity.

2.9.1 IMPACT OF SPECIFIC UNCERTAINTY VARIABLES

A range of workday loss expected at the end of the activity, as obtained from the historical records is input for specific uncertainty variable along with the activity expected to be affected by it. A random sampling from the range gives the simulated workday loss due to the impact of specific uncertainty variables.

2.10 CONSIDERATIONS IN COMBINING THE IMPACT

The preceding discussion has established that the uncertainty variables have significant impact on the activity durations. A method of random sampling the impact on activity durations has been described for each uncertainty variable. Since many of the uncertainty variables occur simultaneously they together affect the activity duration. Only when the impact of an uncertainty variable is mutually exclusive, the expected workday loss occurs irrespective of the impact of other uncertainty variables. Most times it is non-mutually exclusive, making it necessary to combine the workday loss. This is calculated by suitably correcting for the overlap. There are two approaches to correct for the overlap. One is the methodology suggested [5] by Woolery using the following Equation (Equation 2.1).

$$T_t = \left[1 - \frac{\prod_{k=1}^{k} (T_E - t^k)}{(T_E)^k} \right] T_E + T \qquad (2.1)$$

Where

T = time under optimal conditions

T_t = T + total value of collective delay

T_E = T + any estimate of the total or collective delay

K = number of delays

t^K = K^{th} delay

This equation provides an estimate of the new duration after including the collective delay or advancement. The validity of Equation 2.1 has been demonstrated by Woolery [5].

In the second method, as suggested by Carr [13], the fractions of workdays obtained as a result of the impact by each uncertainty variable are multiplied to compute the progress for one day under the combined occurrence of the uncertainty variables. According to him,

Expected progress on a day =(progress under weather conditions)* (progress under space congestion)*(progress under crew absenteeism)*(. . . . . .) etc. This assumes independency of occurrence of the uncertainty variables. There is only marginal difference in the results arrived by both methods. This model considers all uncertainty variables as non-mutually exclusive. The equation 2.1 has been considered with a minor modification. Woolery expressed how a day's work is getting extended due to the influence of the uncertainty variables. By using a reciprocal relation, it is envisaged to calculate the available workday out of a full day. Accordingly, the combined daily workday loss and total number of workdays expected to be lost at the end of an activity is computed using the equation 2.1. This Equation need not be used if an uncertainty variable occurs independently.

Iterative random sampling of the combined impact of significant uncertainty variables for a specified project period results in a duration estimate distribution for each activity.

2.11 MONTE CARLO SIMULATION TO FORECAST PROJECT DURATION

The preceding discussion shows that, due to the influence of the uncertainty variables, the deterministic duration estimates do not give a reliable forecast of project completion time. Therefore, it is relevant to consider a probabilistic duration estimate for each activity. Literature survey indicates that Program Evaluation and Review Technique (PERT) considers a probabilistic duration estimate for each activity. It converts them into an expected value and its associated variance, based on simplified assumptions. A project completion time in the form of a normal distribution is then generated using the mean critical path and variance. The major limitation is that the model ignores path other than the mean critical path when evaluating the probability of completion. This problem is known as " MERGE EVENT BIAS " . This yields an overoptimistic evaluation of the completion time. Research has shown that the actual expected duration can be 50 % higher than PERT mean critical path. The significance of the error is increased as the number of converging path increases. To overcome this problem, Van Slyke suggested [29] that simulation methods such as Monte Carlo could be used.

Monte Carlo simulation provides for experimental sampling of random variables from distribution to generate a random duration for each activity. Those sampled random variables are then used to determine the probability distribution function (PDF) for the project completion time. Monte Carlo simulation method has the following advantages :

1. The resulting project completion time is unbiased.
2. No assumption is made as regards to the shape of the completion time.
3. Any form of input PDF (bimodel,skewed etc.) may be stipulated.
4. It is possible to treat the correlated variables.

The limitation is the large number of iteration to be carried out for obtaining a reliable result.

In this research work, it is proposed to use Monte Carlo simulation method to obtain the project duration forecast from the activity duration distributions.

Chapter 3

THE COMPUTER MODEL

The random sampling described in the preceding chapter is done using a computer model. The model is also intended for determining the probabilistic project duration forecasts using simulations. This chapter describes the computer model.

3.1 COMPUTER MODEL

The computer model, PRoject DUration Forecast [PRODUF] has been developed with the following objectives:

1. To interactively receive the input pertaining to different uncertainty variables.
2. To simulate the project environment by random sampling from project uncertainty variables and to combine their impact in terms of workday loss.
3. To consider on a daily basis the activities expected to be in progress, compute expected progress under simulated project environment and to obtain from it a distribution for all tactical plan activities.
4. To generate from Monte Carlo simulation a distribution for the tactical plan completion time and for the project completion time.
5. To derive other useful management information using the output described in 3 & 4.

Figure 3-1 is a flowchart of PRODUF model which is described in the following sections.

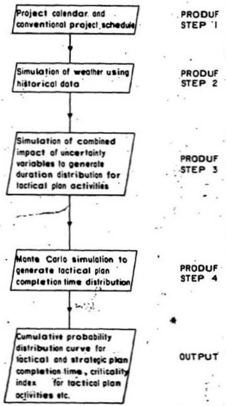


Figure 3-1: PRODUF computer model

3.2 INPUT REQUIREMENTS OF THE MODEL

PRODUF requires as input the following:

1. Strategic and tactical plan activity data
2. Project calendar
3. Historical data on the occurrence of each significant uncertainty variable.

3.2.1 STRATEGIC PLAN

Since sufficient information to plan a project in detail is not available at the start, only a skeleton network, called Strategic plan, is developed using the principal activities and major milestones of the entire project from the begining to the end. The activity data from the strategic plan is required to forecast the project duration. The strategic plan must be updated periodically to reflect latest situation of the project.

3.2.2 TACTICAL PLAN

The tactical plan, a CPM network like the strategic plan, represents a shorter span, but has more details of the project. Tactical plan provides a means of measuring progress and exercising control over operations. Normally tactical plan is made for four reporting periods each of one month duration. As the project proceeds, the tactical plan is progressively extended one period at the time of each progress review so it always represents the current as well as three following reporting periods. The tactical plan activity data is used by PRODUF in all its activity duration distribution calculations. Figure 3-2 shows partially a typical strategic and tactical plan for a project.

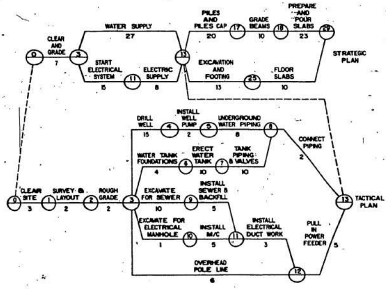


Figure 3-2: Strategic and tactical plans

3.2.3 PROJECT CALENDAR

Project calendar is the yearly calendar for the entire span of the project. PRODUF needs as input the start date of the project, likely finish date of the project and user specified holiday list.

3.2.4 HISTORICAL DATA ON UNCERTAINTY VARIABLES

Since the degree of significance of the impact of individual uncertainty variables varies for different activities, the significant uncertainty variables along with the tactical plan activities likely to be affected by them are tabulated. Part of such data is shown in Table 3-1. The details of the expected range of workday loss due to the impact of weather is given in Table 3-2. Similar data for the remaining uncertainty variables are given in Appendix A.

3.3 UNCERTAINTY VARIABLES INPUT AND SIMULATION OF THEIR IMPACT

Data based on Table 3-1 and 3-2 are systematically input interactively and stored for use to simulate the project environment. The details of the required input as well as of the simulation performed for each significant uncertainty variable follows.

LEARNING CURVE

Activity Number	Description	Learning Curve	Weather	Space Congestions	Crew Absenteeism	Design Changes & Rework	Regulatory Requirements	Economic Activity Level	Labour Unrest	Specific Uncertainty Variable
1.	Clear Site	✓	✓	–	✓	–	–	✓	–	–
2.	Survey & Layout	–	✓	–	–	–	–	✓	–	–
3.	Rough Grade	–	✓	–	–	–	–	✓	–	–
4.	Drill Well	✓	✓	–	–	–	–	✓	✓	✓
5.	Foundation Watertank	–	✓	–	–	✓	–	✓	✓	–
6.	Excavate for Sewer Main	✓	✓	–	✓	–	–	✓	✓	✓

Table 3-1: Impact of significant uncertainty variables on activities

Table 3-2: <u>Workday loss expected due to the impact of weather</u>

Number of activities affected : 34
Affected activity numbers : 1 to 36 except 18 & 29

Node From-to	description	Temp <0	<10	Rain >10 mm	snow >5 cm
0-1	Clear site	0.3	0.2	0.5	0.5
1-2	Survey and L/o	0.3	-	0.5	0.5
2-3	Rough grade	0.3	0.1	-	-
3-4	Drill Well	0.3	0.1	0.5	0.5
3-6	Found.W.T	0.3	0.1	0.4	0.5
3-9	Exca.for sew.	0.3	0.2	0.5	0.5
3-10	Ex.manhole	0.3	0.1	0.4	0.5
3-12	Overhead pole	0.5	-	0.2	0.5
4-5	Ins.Wellpump	0.3	0.1	0.2	0.25
5-8	Undergr.W.P	0.3	0.1	0.5	0.25
6-7	Erect W.T	0.5	0.1	0.2	0.2
7-8	Tank pipe	0.2	-	0.2	0.2
8-13	Connect pipe	0.4	-	0.1	0.1
9-11	Install sew.	0.4	0.3	0.5	0.5
10-11	Ins.manhole	0.3	0.2	0.4	0.4
11-12	Inst.El.Duct	0.4	0.3	0.5	0.5
12-13	Pull po.feed	0.2	0.1	0.5	0.5
13-23	Exca.office	0.3	0.2	0.5	0.5
14-15	Piles	0.3	0.2	0.5	0.5
15-16	Exca.W/H.	0.4	0.3	0.5	0.5
16-17	Pour pi.cap	0.3	0.2	0.5	0.5
17-18	Form&Pour	0.3	0.2	0.5	0.5
18-19	Backfill	0.2	-	0.3	0.3
18-21	Form R/1	0.3	0.2	0.5	0.5
18-22	Form L/H	0.3	0.2	0.5	0.5
19-20	U/S plumb	0.1	-	0.2	-
20-22	U/S condui.	0.2	-	0.1	0.1
22-29	Form & po.	0.3	0.2	0.5	0.5
23-24	Spread foot	0.3	0.2	0.5	0.5
24-25	Form&Pour	0.3	-	1.0	0.2
25-26	B/F&Compact	0.2	0.1	0.5	0.2
26-27	U/S plumb	0.3	0.2	0.2	0.1
27-28	U/S Condui	0.3	0.2	0.2	0.2
28-29	Form&pour	0.3	-	1.0	0.2

Input: Activities likely to be affected, volume of work, duration, time required to carry out unit volume of work, variation expected in decremental constant for such activities.

- Simulates the decremental constant and computes the revised duration for activities.

WEATHER

Input: Activities likely to be affected, past(10 or more years) weather data such as maximum temperature, rain, snow, and workday loss expected on each workday if activities face different weather conditions such as temp less than 0 °C, rain > 15 mm etc.

- Simulates a set of weather data for each project day from the given historical records and calculates the expected workday loss for activities planned on that day. The workday loss may be either for the whole day or a part thereof.

SPACE CONGESTION

Input: List of congested zones with total space available in each, activities likely to be affected, and space requirement for each in its designated zone.

- Simulates space requirement of activities planned for each day to determine any possible space congestion. In case of congestion, delays the activities that have float and computes for the critical activities the workday loss due to decreased productivity.

CREW ABSENTEEISM

Input: Activities likely to be affected, monthly range of percentage absenteeism separately for midweek days and weekend/week-begining days, monthly manpower requirement for the tactical plan period and range of expected workday loss corresponding to the number of workmen absent.

- Simulates for each day the number of absentees based on percentage absenteeism and total manpower. Next, distributes randomly the absentees over the activities planned on each day and calculates the workday loss due to the absentees.

REGULATORY REQUIREMENTS, DESIGN CHANGES AND REWORK

Input: Activities likely to be affected, range of expected daily workday loss and range of number of workdays expected to be lost at the end of an activity.

- Simulates for each activity, the expected daily workday loss and total number of workdays expected to be lost at the end.

ECONOMIC ACTIVITY LEVEL

Input:Equation for the relation between the productivity adjustment factor and the ratio of workmen required to their availability and the expected value of this ratio for each month of the tactical plan.

- Computes the productivity adjustment factor and multiplies it by the available workday. This, it does for each tactical plan month.

LABOR UNREST

Input: project days expected to have labor unrest, activities likely to be affected, and the expected workday loss.

- Computes for activities the workday loss during the days of labor unrest.

SPECIFIC UNCERTAINTY VARIABLE

Input: Activities likely to be affected by a specific uncertainty variable and expected range of delay due to it's impact.

- Simulates for each activity the total number of workdays expected to be lost at the end.

PRODUF first simulates the impact on the activities of those uncertainty variables that are independent of the time of the year and then proceeds to simulate for each day the impact of the time dependent uncertainty variables. Having completed the input requirements and the simulation of the project uncertainties, the discussion now proceeds with how the model forecasts project duration.

3.4 PRODUF PROCESSING

The working of PRODUF model can be explained in four steps as shown in Figures 3-3 to 3-6. Initially, based on the input for strategic and tactical plan, and project calendar, PRODUF generates the workday and calendar dated project schedules meant for the executive level management. It receives and stores all input pertaining to the uncertainty variables required for impact computations. This comprises step 1 as illustrated in Figure 3-3. The next step involves random sampling from the weather data input for the tactical plan period, as shown in Figure 3-4.

Having received all input in the first two steps, in step 3, PRODUF proceeds as shown in Figure 3-5, with computing separately the workday loss due to the impact of the uncertainty variables. Starting with project day 1, PRODUF considers the tactical plan activities in the early start sequence and estimates for each the revised duration based on learning curve effect. Following this, the impact of the individual uncertainty variables is considered and the expected workday loss is calculated for each. Then, using Equation 2.1, the impact of the uncertainty variables on the activity duration is combined as explained in the preceding chapter. The computations aim at determining whether the whole or only a part of the workday is available for the activity. The fraction representing the available workday reflects the ratio between the productivity computed

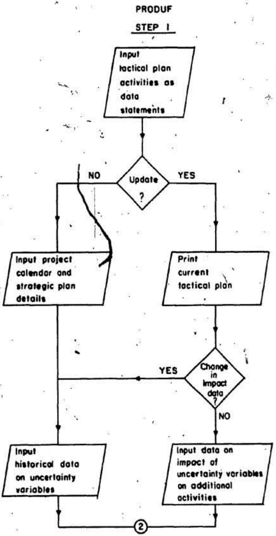


Figure 3-3: PRODUF processing-step 1

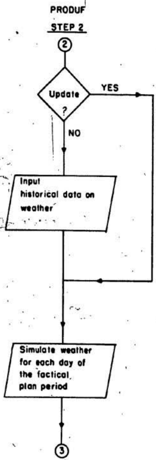


Figure 3-4: PRODUF processing-Step 2

for the simulated project environment for the day and the estimate of the average productivity used in determining the original activity duration. At the end of the day, PRODUF, by subtracting the available workday from the duration of the activity, calculates the remaining duration required to complete the activity. This is done for all activities expected to be performed on project day 1. PRODUF proceeds to project day 2, 3, 4 and so on, until the estimated duration of an activity in progress is finished although the activity is incomplete. At this stage, the early start and finish dates of all incomplete activities are updated. When the remaining duration for any activity becomes zero, it is considered complete and the total elapsed days on that activity represent its expected duration under simulated project environment. Situations in which the remaining duration is a fraction of a day, are also considered and durations are estimated upto 1/2 of a day. If the activity is expected to have several days delay at the end, PRODUF combines such delays, corrects for overlap, and then determines the final expected duration of the activity. After all the tactical plan project days have been considered the tactical plan activities are expected to be in one of the following categories:

- complete
- in progress
- yet to start.

Since it is impractical to predict in a quantitative manner, with any degree of confidence, the impact of the uncertainty variables for a span longer than three reporting periods, the duration estimates of those activities that do not start within the three reporting periods under consideration are not revised. Further, to obtain the expected duration for an activity in progress, the remaining duration required to complete the activity is added to the number of days elapsed. These computations give a set of expected durations for each tactical plan activity in the simulated environment. The result represents one outcome of an infinite number of possible outcomes under the described uncertainty. At this point it is necessary to discuss the means of fixing the number of simulations required to adequately represent all possible variations of the project environment. The number of simulations are determined from the statistical analyses of the project data. Assuming that the activity duration follows a Beta distribution, the number of simulations can be computed using the following relationship:

$$N=1/\alpha^2(2-1/p)$$

where

N = the number of simulations

α^2 = Error parameter, and

P = Beta distribution parameter

The value of P depends on the shape of the Beta distribution curve. Assuming a value of 2 for P and $\alpha^2 = 0.05$, N then becomes equal to $1/0.05[2-1/2] = 30$

It is general statistical practice to consider 30 simulations to get an estimate of the population parameters. Accordingly 30 simulations are considered for the example. Each iteration simulates a new combination of expected project environment and computes the corresponding set of expected duration for the tactical plan activities. A distribution of expected duration for each tactical plan activity is obtained from these simulations. The duration distribution is similar to PERT duration distribution with the following exception:

1. A distribution for activity duration estimate is available instead of just three time estimates.
2. The distribution is obtained from simulation while PERT estimates are obtained intuitively.

Next the final step of PRODUF processing is flowcharted in Figure 3-6. The tactical plan network has a distribution of activity durations. Using Monte Carlo simulation, a random duration for each activity can be generated. Forward and backward pass computations for each set of random durations are carried out to compute the expected completion time. This is done iteratively to obtain the distribution for expected tactical plan completion time. A typical cumulative distribution for tactical plan completion time is shown in Figure 3-7.

After start of a project, PRODUF carries out simulation at the time of each progress review. Additional input data required at each update follows.

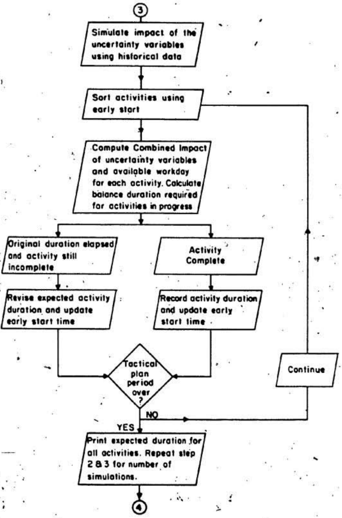


Figure 3-5: PRODUF processing Step-3

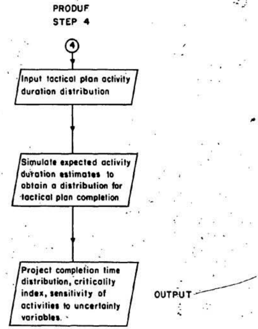


Figure 3-6: PRODUF working-Step 4

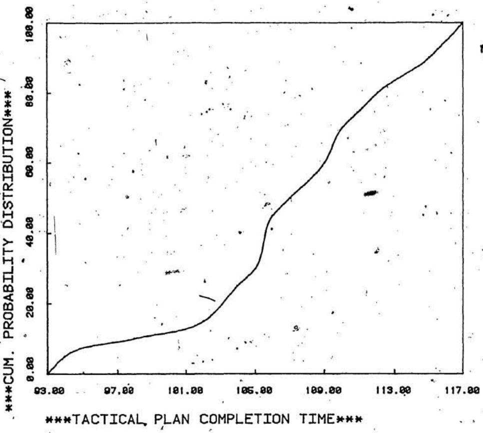


Figure 3-7: C.P.D. for tactical plan completion time

i) "Time now" and the last day of the tactical plan period.

ii) activities completed

iii) activities in progress and their remaining duration.

iv) activities added, deleted or modified since the last progress review.

v) Any modification to the input data relating to uncertainty variables.

At each progress review, PRODUF adds or modifies the recorded data, processes it for computing the project completion time and evaluates the probabilty distribution for the tactical plan completion time. This forecast forms the basis and along with the strategic plan, is used to generate probability distribution for project duration forecast as explained in the following chapter.

Chapter 4

EXAMPLE PROJECT

4.1 PROGRAM STRUCTURE

The computer program, comprised of four subprograms:PRODUF 1, 2, 3, and 4 as described in the preceding chapter, receives and stores all input data on the uncertainty variables, generates project schedules, simulates the impact of the uncertainty variables and derives a duration distribution for each tactical plan activity. It then carries out Monte Carlo simulation to generate completion time. It also computes the criticality index. The criticality index of an activity can be defined as the ratio of the number of times an activity becomes critical to the total number of times the project duration is simulated. The program listing for PRODUF. is given in Appendix B.

The working of PRODUF and the analysis of its output is explained with the help of an example project.

4.2 BRIEF DESCRIPTION OF THE PROJECT

The construction of a combination plant-office-warehouse for a small industrial firm is the project considered [28]. A floor plan of the entire complex is shown in Figure 4-1. The site is in a low area overgrown with scrub timber and bushes; the soil is a sand and gravel mixture overlaid by clay. Cast-in-place piles will be driven to about 30 feet for the plant and warehouse foundations. The office building will be on spread footings. As there is no water supply available, a well and 50, 000 gallons elevated water tower will be installed. Sewerage and power trunk lines are 2000 feet away. The plant and warehouse structures are to be structural steel with high tensile bolted connections. The plant will have an overhead crane way running through the length of the building. The warehouse will have a monorail. The roof system will be bar joists and precast concrete planks covered with 20 year built up roofing.

4.3 STRATEGIC AND TACTICAL PLANS

When the project is initiated, a strategic Plan in the form of a CPM network is prepared as shown in Figure 4-2. The estimated project completion time is 285 days. To account for the combined impact of the uncertainty variables, a fictitious activity, with 15 days duration, equal to the contingency time allowance is provided at the end. So the project is expected to be completed within 300

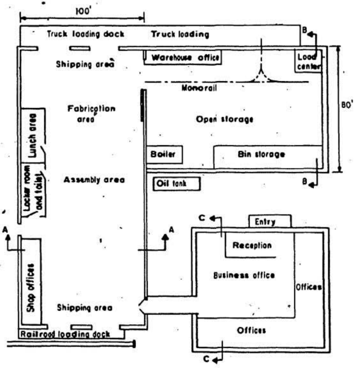


Figure 4-1: Floor plan of the project

project days. The first tactical plan covering four reporting periods of one month each, is shown in Figure 4-3. Using the strategic and tactical plan, as well as the following calendar information as input, workday and calendar date schedules are generated separately for the strategic and tactical plans and are included alongwith the project calendar in Appendix C .

Start date of the project	05-01-1984
Likely finish date	12-31-1985
Weekly off	Sat, Sun
Annual holidays	08-15-1984
	12-25-1984
	04-20-1985
	08-15-1985
	12-25-1985

The tactical schedule forms the basis for incorporation of the impact of the uncertainty variables. The input data for the first tactical plan period are shown in Table 4-1. The data are supposed to be obtained from the company archives. To simulate the expected project environment and its impact, PRODUF uses the sequence number of the simulation run as the seed number. PRODUF considers all the

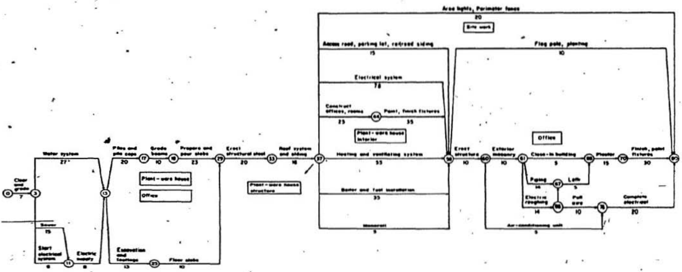


Figure 4-2: Strategic plan

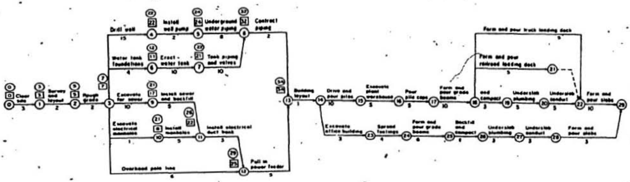


Figure 4-3: Tactical plan

Description of the uncertainty variable	Total no.of acty.affected	Activity numbers
Learning Curve	17	1,4,6,7,10,12,13,19,20 21,22,23,25,26,30,32 and 36
Weather	34	1 to 36 except 18 and 29
Space congestion	5	6,7,25,27,28
Crew absenteeism	35	1 to 36 except 29(See Appendix A for percent absenteeism)
Regulatory requirements	5	4,8,14,16 & 17
Design changes and rework	5	4,11,13,25 & 31
Economic activity level	35	1 to 36 except 29(see Appendix A for the equation and the value of the ratio)
Labor unrest	22	4,5,6,7,11,12,13,19, 20,21,22,23,24,26,27, 28,30,31,32,34,35 & 36
Specific uncertainty variable	8	4,6,8,14,15,27,33,35

Note:

1. Details of the impact are given in Appendix A.

2. For detailed activity description and node numbers, refer to Table 4-3 and Figure 4-2.

Table 4-1: Input data for the tactical plan -first reporting period

36 activities of the tactical plan and sorts in ascending order of early start, the activities planned on each day. On project day 1, only one activity, Clear Site, is planned;its revised duration based on learning curve impact is 3.5 days. The expected impact due to each uncertainty variable is determined in terms of workday loss and successively combined. For the activity, Clear Site, the work that can be done under the simulated project environment is 0.8 of the planned progress on project day 1. Therefore, the balance duration required for this activity is 2.7 days(3.5-0.8). Since there are no more activities to be performed on that day, PRODUF proceeds to project day 2. Here again, the same activity is in progress and the impact is simulated as before. Similar consideration for project day 11 and 12 are shown in the computer printout in Table 4-2. When all the 88 project days have been considered, the tactical plan activities will show the following status in the first simulation run:

Activities expected to be completed	29
Activities expected to be in progress	3
Activities expected not to start	3
Dummy activity	1

To obtain the expected duration for an activity in progress, the number of days elapsed is added to the

DAY	DATE	ACTY. NO	DESCRIPTION	NO. OF DAYS COMPLETED
11	15/ 5/84	4	DRILL WELL	1
11	15/ 5/84	5	FOUND. WELL	1
11	15/ 5/84	6	EXCA. FOR SEWARAGE	1
11	15/ 5/84	7	EXCA. MANHOLE	1
11	15/ 5/84	8	O.H. POLE	1

AVAILABLE WORKDAY FOR ACTIVITY 4 IS 1.03 DAY
AVAILABLE WORKDAY FOR ACTIVITY 5 IS 1.03 DAY
AVAILABLE WORKDAY FOR ACTIVITY 7 IS 1.03 DAYS
AVAILABLE WORKDAY FOR ACTIVITY 8 IS 1.01 DAY
BALANCE DURATION FOR ACTIVITY 4 IS 11.98 DAYS
BALANCE DURATION FOR ACTIVITY 5 IS 3 DAYS
BALANCE DURATION FOR ACTIVITY 6 IS 9.24 DAYS
BALANCE DURATION FOR ACTIVITY 7 IS 6 DAYS
ACTIVITY 7 IS COMPLETED. THE DURATION IS 1 DAY.
BALANCE DURATION FOR ACTIVITY 8 IS 5 DAYS.

ACTY	ES	EF	LS	LF
4	10.5	10.5	28.5	28.5
5	10.5	10.5	15.5	15.5
6	10.5	13.5	20.5	23.5
7	10.5	25.5	11.5	26.5
8	10.5	29.5	16.5	35.5

12	16/ 5/84	4	DRILL WELL	2
12	16/ 5/84	5	FOUND. WELL	2
12	16/ 5/84	6	EXCA. FOR SEWARAGE	2
12	16/ 5/84	8	O.H. POLE	2
12	16/ 5/84	15	INSTALL MANHOLE	1

AVAILABLE WORKDAY FOR ACTIVITY 4 IS 0.84 DAY
AVAILABLE WORKDAY FOR ACTIVITY 5 IS 1.03 DAY
AVAILABLE WORKDAY FOR ACTIVITY 6 IS 0.89 DAY
AVAILABLE WORKDAY FOR ACTIVITY 8 IS 0.846 DAYS
AVAILABLE WORKDAY FOR ACTIVITY 15 IS 0.858 DAYS
BALANCE DURATION FOR ACTIVITY 4 IS 11.18 DAYS
BALANCE DURATION FOR ACTIVITY 5 IS 2 DAYS
BALANCE DURATION FOR ACTIVITY 6 IS 8.34 DAYS
BALANCE DURATION FOR ACTIVITY 8 IS 4.1 DAYS.

Table 4-2: Computer printout for available workday on day 11 and 12 remaining duration required to complete the activity. For the activities that are not likely to start in the tactical plan period, the original estimated duration remains unchanged. The expected duration estimates of all tactical plan activities from the first simulation run are shown in Table 4-3. This completes one simulation resulting in one set of expected duration estimates for all tactical plan activities. As explained in the preceding chapter, it is estimated that 30 simulations are expected to give a reasonable cross section of the occurrence of the project environment. Accordingly, 30 simulations are carried out in a similar manner to represent many outcomes of the project environment and the corresponding activity duration estimates. Expected duration estimates separately for each activity from all simulation runs are sorted in ascending order to obtain a range and a distribution of duration estimates for each tactical plan activity. For example, the original estimated duration for activity Tank pipe Installation is 10 workdays. The simulated duration estimates are the following:

7, 8, 8.5, 8.5, 9, 9, 9, 9, 10, 10, 10.5, 11, 11, 11.5, 11.5, 12, 12, 12, 12, 12.5, 13, 13, 13.5, 13.5, 15, 15, 15, 15, 16, 16, and 16.5 workdays.

From the frequency of occurrence of the duration estimate, the expected activity duration distribution is obtained. It will be observed that there is 0.33 chance that the activity duration will be 10 days, as estimated

Table 4-3: Estimated activity durations from simulation 1

ACTY NO.	FROM	TO	DESCRIPTION	DURATION
1	0	1	CLEAR SITE	4.5
2	1	2	SURVEY&L.O	3
3	2	3	ROUGH GRADE	2
4	3	4	DRILL WELL	18
5	3	6	FOUND.WELL	5.5
6	3	9	EXCA.FOR SEWAR.	11
7	3	10	EXCA.MANHO	1
8	3	12	O.H.POLE	7
9	4	5	INSTALL W.P	3
10	5	8	U.G.W.P	7
11	6	7	ERECT W.T	13.5
12	7	8	TANK PIPE	10
13	8	13	CONNECT PIPING	5
14	9	11	INSTALL SEWAR	10
15	10	11	INSTALL M/H	6
16	11	12	INSTALL ELEC.DUCT	4
17	12	13	PULLIN P/FEED	7
18	13	14	BLDG L/O	1
19	13	23	EXCA.FOR OFF	5
20	14	15	DRIVE &POUR PILE	13
21	15	16	EXCA.PLA W/H	6
22	16	17	POUR PILE CAP	5.5
23	17	18	FORM AND POUR	10
24	18	19	BACKFILL	7
25	18	21	FORM & POUR R/L	9.5
26	18	22	FORM & POUR T/L	5
27	19	20	U/S PLUMB	5
28	20	22	U/S CONDUIT	5
29	21	22	DUMMY	0
30	22	29	FORM & POUR	10
31	23	24	SPREAD PLOT	6.5
32	24	25	FORM&POUR	6
33	25	26	B/F&COMPACT	1
34	26	27	U/S PLUMB	4
35	27	28	U/S CONDUIT	4
36	28	29	FORM&POUR	4

originally. ~~The duration estimate for this~~ activity under most favourable project environment will be 7 workdays. Under least favourable project environment, it will be finished in 16.5 workdays.

4.4 MONTE CARLO SIMULATION OF THE COMPLETION TIME

Monte Carlo simulation uses the expected activity duration distribution and generates in each iteration one set of duration estimates for all tactical plan activities. It then produces the tactical plan completion time for the set. Iterative simulations result in a distribution for the tactical plan completion time from which the cumulative distribution is obtained for the tactical plan completion time as shown in Figure 4-4. Next, the original schedule is compared with the simulation output. The original strategic and tactical plan completion time along with the appropriate contingency allowance is shown in Figure 4-5(a). The project is yet to start;its simulation will start from May 1, 1984, the start date considered for the project. The tactical plan ends on 88th project day. The total project completion time, 300 workdays, includes 15 workdays towards contingency time allowance. The original completion time for the tactical plan, including a proportionate contingency time allowance of 4 workdays, is 92 workdays. The simulation results are shown in Figure 4-5(b) and (c). The cumulative probability distribution for the tactical plan period is also shown in Figure 4-5 (d). It will be seen

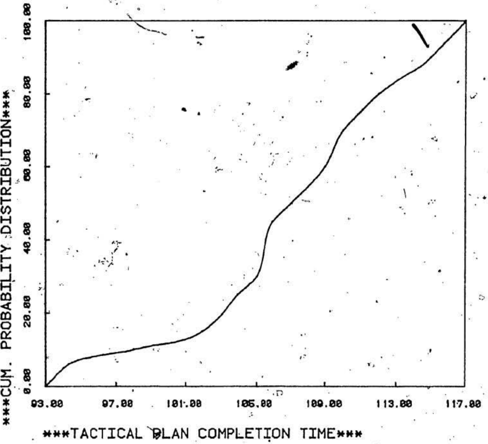


Figure 4-4: C.P.D. for tactical plan completion time

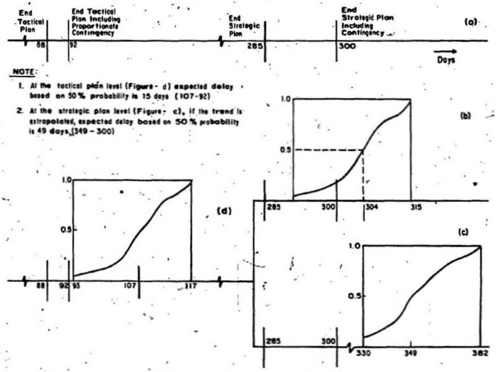


Figure 4-5: Completion time-original with simulated forecast

that completion of the tactical plan within the original duration including the proportionate contingency time allowance is not feasible. Another conclusion is that, if the project tactical plan proceeds without any acceleration, the expected delay in the tactical plan, based on 50 percent probability will be 15 workdays.

Next, PRODUF relates the simulation results to the strategic plan. There are two alternatives. Alternative 1 is optimistic and assumes that the activities in the strategic plan period will be completed as per the original duration and the expected delay is only in the tactical plan period. In that case, the project completion time distribution is similar to the tactical plan distribution obtained earlier as shown in Figure 4-5 (d). The expected project completion time corresponding to 50 percent probability is 304 workdays. This optimistic forecast reflects a favourable future project environment.

Alternative 2 assumes that the expected delay in the strategic plan with respect to the tactical plan delay is proportionate to the time span of the two plans. Figure 4-5 (c) shows the distribution of completion time for the tactical and strategic plans. The expected project completion time corresponding to 50 percent probability is 349 workdays. It will also be observed that the distribution pattern differs from that of Alternative 1. This highlights the need for the management to offset delays during the tactical plan so they do not get magnified in the strategic plan.

The criticality index for each activity of the tactical plan is computed from simulation results as shown in Table 4-4. The output discussed here is available immediately before the project starts, so the management can take advance remedial measures to prevent any schedule delays.

Assuming that the project has been in progress for two reporting periods, on July 1, 1984, the beginning of the third reporting period, progress data is input for updating the project schedule. During the two previous reporting periods, certain activities have been completed. Some activities are expected to be in progress and need time to complete. This progress status is presented in Table 4-5. Ten new activities are added to the preceding tactical plan. The tactical plan now extends upto Sept 30, 1984, the 124th project day. The tactical plan data is updated and the latest information on the impact of the uncertainty variables is added.

PRODUF starts simulation of the project environment one day at a time, for the tactical plan period, computes the combined impact of the uncertainty variables in terms of workday loss and obtains duration distribution for each activity. Monte Carlo simulation is carried out as before to get a distribution of completion time for the tactical plan. The completion time distribution for the tactical plan and the strategic plan, on similar lines as for reporting period 1 shown in Figure 4-5, are indicated in Figure 4-6 (b), (c), and (d). Figure 4-6 shows a

Activity number	Criticality index	Activity number	Criticality index
1	1.00	19	–
2	1.00	20	1.00
3	1.00	21	1.00
4	0.75	22	1.00
5	0.20	23	1.00
6	0.04	24	1.00
7	–	25	–
8	–	26	–
9	0.85	27	1.00
10	0.85	28	1.00
11	0.08	29	–
12	0.08	30	1.00
13	1.00	31	–
14	0.04	32	–
15	–	33	–
16	0.04	34	–
17	0.04	35	–
18	0.04	36	–

Table 4-4: Criticality Index - First reporting period

"Time now"	Begining of third reporting period
Activities completed	1 to 22
Activity in progress	23
Remaining duration for activity 23	5
Activity just to start	31
Any change in activity duration	nil
Current tactical plan start day	45
Current tactical plan end day	124
Data relating to uncertainty variables	
Economic activity level	
Ratio for tactical plan period	
July	0.8
August	0.8
Sept.	0.8

Note:No other changes in the impact data.

Table 4-5: Project progress table

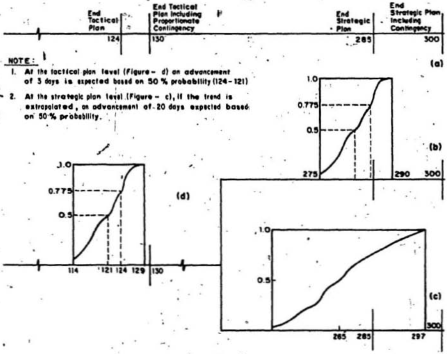


Figure 4-6: Completion time-original vs simulated at end of second period

probability of 77.5 percent that the tactical plan will be carried out as per schedule (including proportionate contingency time allowance). Extrapolating the trend for the strategic plan, the cumulative probability distribution of completing the project on project day 285 is also 77.5 percent. When the contingency time allowance is included, no delay is expected and the project is expected to be completed within schedule. Also, the criticality index for the tactical plan activities is computed as shown in Table 4-6.

On comparison of this forecast against the forecast made for the first reporting period, it is observed that the project is progressing well and efforts to offset any delay that could have been caused by the uncertainty variables have been fruitful. It is evident that the original schedule will hold and does not need a revision.

Similar updates and simulations at each reporting period till the project is complete provide management with a forecast of project duration. Being generated from simulation of the project environment, it will be more reliable than the one derived from intuitive consideration.

Activity number	Criticality index	Activity number	Criticality index
23	0.95	34	0.05
24	0.95	35	0.05
25	-	36	0.05
26	-	37	1.00
27	0.95	38	1.00
28	0.95	39	1.00
29	-	40	-
30	0.95	41	0.85
31	0.05	42	1.00
32	0.05	43	1.00
33	0.05	44	1.00

Table 4-6: criticality index - Third reporting period

Chapter 5

PRODUF APPLICATIONS AND LIMITATIONS

PRODUF generates and updates project schedules, incorporate the impact of the uncertainty variables on the activity duration estimates, and produces the probabilistic forecast of project duration. It has the following applications.

5.1 APPLICATIONS

5.1.1 FORECASTING PROBABILISTIC COMPLETION TIME

PRODUF can be used to forecast probabilistic project completion time. Forecast plots made at the beginning of first and third reporting periods were shown in Figures 4-5 and 4-6 respectively. These plots show the probabilistic trend of achieving the original schedule.

As already stated, PRODUF also generates information on individual activities which can provide additional insight into the project. Based on the expected duration distribution of each activity, management can focus its extra attention on such activities that have greater likelihood of deviating from the original duration. Time/cost trade off decisions to offset the delay can be taken by the management.

5.1.2 CRITICALITY INDEX

The criticality index of an activity is of great importance for management by exception. PRODUF generates a more reliable criticality index since it takes into account the combined impact of the uncertainty variables.

5.1.3 SENSITIVITY TO UNCERTAINTY VARIABLES

PRODUF identifies the significant uncertainty variable that is expected to cause most delay in an activity. This helps management to take timely preventive action.

5.1.4 CONTINGENCY ALLOWANCE

PRODUF can be used to make a realistic estimate of contingency time allowance for the project. By a suitable extrapolation from the forecast of expected delay for the tactical plan period, the contingency time allowance can be estimated.

5.1.5 GAMING MODEL

Construction management games like"CONSTRUCTO" or"PERTSIM" have been developed to give the student confined to the academic setting, an opportunity to develop the skeleton of his own response by confronting him with problems in the game environment similar to those actually encountered on job site. PRODUF, with minor modifications, can also be used as a gaming model for facilitating students learning. The following will be its main features:

1. Use of microcomputers compared with the existing models on mainframe computers.
2. Incorporation of the combined impact of a larger number of uncertainty variables.
3. Extensive use of historical data on uncertainty variables for a specific project.
4. More realistic probabilistic forecast of project delay to enhance student's understanding of the impact of the uncertainty variables.

As an extension of its application as a gaming model, PRODUF can also be used for personnel selection.

5.1.6 APPLICATION OF PRODUF ON A HYDRO PROJECT

PRODUF model has been effectively used on a hydro project. The project was under construction and the dam at east and west were simultaneously in progress when the model was used. It had a diversion tunnel to drain the runoff collected in the reservoir. The gate to the diversion tunnel was to be closed permanently when the reservoir was ready to store water. The management would like to commission the project in November or December 1984 as soon as the construction was over. To store maximum water in the reservoir for generating electricity, the diversion gate must be closed as early as possible so that enough of the 1984 spring runoff would be stored. Since the two dams were expected to be constructed during the Spring and must not be overtopped, a suitable date for gate closure had to be selected which would satisfy both constraints.

The following input data was given by the consultant:

1. Temperature, precipitation, runoff etc. for a period of 15 years for each day of the year.

2. Relationship between construction productivity and weather conditions based on past performance.

3. Equation relating height of dam with the volume of fill for each of two dams under construction.

From the available weather data, PRODUF simulated weather for each project day. Daily construction progress and the resulting dam height were computed using simulated weather conditions, observed weather productivity relationships and the workday type (off day, half workday, full workday or double shift). Once the required dam height was reached, the construction was stopped and the model printed the dam height for each day as shown partially in Appendix D. As a starting point, the model considered a given date for diversion gate closure and generated an optimum date so that the water level in the reservoir was maintained at least one metre below the dam height reached on that day. This prevented overtopping of the dam. In the meantime, while construction was in progress, the spring runoff was being stored. A distribution of gate closure dates was plotted from simulation of reservoir water level and dam height as shown in Figure 5-1. The management selected the gate closure dates commensurate with the risk it wanted to take. Figure 5-2 shows the cumulative distribution for the gate closure dates. It shows that there was no chance of the dams being overtopped if the diversion gate was closed on May 25, 1984. In addition, the model generated cumulative distribution curve for the likely start dates of dam construction as shown in Figure 5-3. Also, depending on different gate closure dates and simulated runoff, distribution was obtained of the dates when the lowest supply level required to generate electricity would be reached. A cumulative distribution for the date when the lowest supply level would be reached is shown in Figure 5-4. Thus, PRODUF provided the management with valuable information to plan its construction and commissioning programs.

Two observations can be made; first, the forecast of gate closure date is based on 15 years weather data provided by the consultant. It does not provide for hazards such as 1 in 50 year flood situations. Second, only one uncertainty variable, weather, is considered significant for this problem.

5.2 SPECIAL FEATURES

1. The model does not interrupt the existing procedures for collecting progress data, processing it and providing the field staff with updated action reports. It utilizes the historical data relating to the uncertainty variables to effectively forecast expected project delay or advancement during its tactical plan period. In case of an expected delay, the forecast alerts the management on the need for taking corrective action before problems arise.

2. The model is an aid for incorporating the impact of the uncertainty variables thereby permitting even the less experienced personnel to forecast project duration with a degree of accuracy and thoroughness.

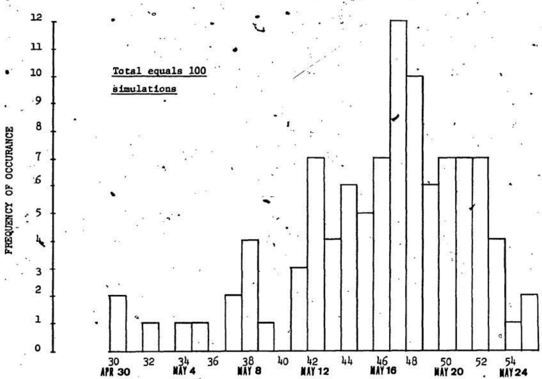


Figure 5-1: Frequency distribution for gate closure dates

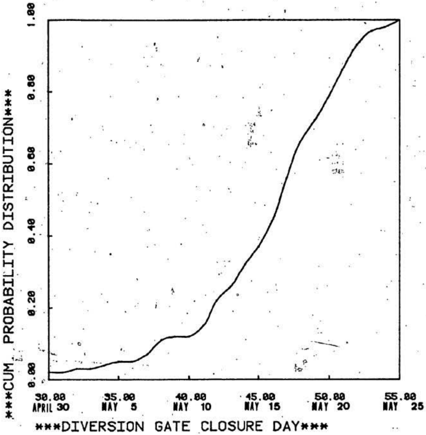


Figure 5-2: C.P.D. for gate closure dates

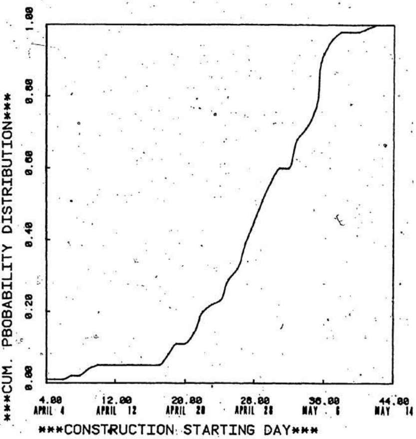


Figure 5-3: C.P.D. for construction start dates

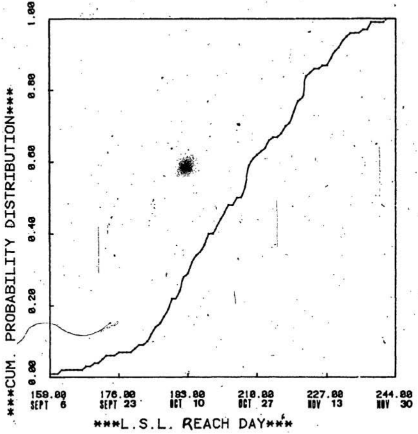


Figure 5-4: C.P.D. for lowest supply level reach dates

3. It makes the management aware of the need to revise the schedule when the project can no longer be brought back to its original schedule.

5.3 FLEXIBILITY

PRODUF has been written in BASICA for use in microcomputers. Unlike package programs, the user has access to the program and can suitably modify it to his/her requirements. Bypassing the impact considerations is possible so as to generate conventional reports suitable to field staff. Since it works on microcomputers, PRODUF can be applied to small and medium size projects and can be used in remote areas.

At this stage, it is relevant to discuss the limitations of the model.

5.4 LIMITATIONS

1. The impact of various uncertainty variables are considered only for four reporting periods represented by the tactical plan. However, the limitation helps keep the model within the realm of realism because it is impractical to predict with any degree of confidence the impact of the uncertainty variables for a period longer than four reporting periods.

2. The model has its foundation in the historical data on uncertainty variables and its impact to refine the activity duration estimate and as such, the reliability of the output will be in direct proportion to the accuracy of the input data. Until the required information for all the significant uncertainty variables is not available, it is possible to limit the impact considerations to those variables for which the data is currently accessable. In the meantime, steps can be taken to collect data for future applications.

3. Although the model uses a range of distribution for the occurrence of individual uncertainty variables, it can use any given distribution. The use of such refined data will further enhance the reliability of the forecast generated by the model.

Chapter 6
CONCLUSIONS

It is a well known fact that the project environment considered while estimating an activity duration at the planning stage does not remain static during its implementation. The intuitive consideration of the combined impact of the dynamic uncertainty variables, while revising activity durations, many times fails to produce a reliable forecast of project completion time. The need for a model which can simulate the project environment to incorporate the combined impact of the uncertainty variables in the activity duration estimates was identified as the problem for this research study. A set of selected uncertainty variables considered significant were studied in detail and suitable methodologies for random sampling were devised to quantify their expected combined impact on the activity duration estimates.

A computer model "PRODUF" has been developed to comprehensively simulate the dynamic uncertainty variables and incorporate their combined impact on activity duration. PRODUF, starting with the deterministic duration of an activity, computes a distribution of duration estimate for each activity. It then carries out Monte Carlo simulation on activity duration distributions to give a probability distribution for the tactical plan completion time. This forecast has been used to develop project completion time forecast from the strategic plan at every progress review.

An example project was considered to explain the working of the model.

Many applications of PRODUF were explained. Among them are the generation of management information including activity duration distribution, criticality index for tactical plan activities, sensitivity of an activity to an uncertainty variable.

Contributions from any research work are normally identified under two major categories;first, advancement of the state of the art in the relevant field and second, practical use of the research work. This research work justifies its inclusion under both categories because of the following reasons:

1. The state of art has been advanced by detailed studies carried out on the uncertainty variables and development of methodology to account for their combined impact on activity duration estimates.

2. PRODUF uses microcomputers keeping in view the current computer technology status.

3. Many potential applications of PRODUF are described. Its practicality has been validated by using PRODUF on a hydro project.

4. PRODUF can be used as an improvised gaming model in project scheduling as a teaching aid in project management field.

5. PRODUF can be applied to medium to large size

> projects because it is designed for microcomputers and can be used with the available data for any number of uncertainty variables at any stage of the project.It is run as and when specific questions need to be answered and as such is an inexpensive aid;when top level management reports need not be generated it can be used as a conventional updating system for functional management.

PRODUF is thus a major addition to the repertoire of the existing project scheduling tools available in microcomputers.

REFERENCES

1. Ahuja H.N and Nandakumar V., "Enhancing Reliability of Project Duration Forecasts"., Transactions of American Association of Cost Engineers, 28 th Annual meeting, June 1984, Montreal.

2. Ahuja H.N., "Project Management:Techniques in Planning and Controlling Projects", John Wiley and Sons, Newyork, April 1984.

3. Taylor Robert C, Stason Ronald C et al "Project Management Under Uncertainity", Project Management Journal, Vol XV, No 1 March 1984.

4. Rich Charland, "Cost Control Needed to Avoid Another TQM Fiasco", Canadian Petroleum, Dec 1983.

5. Woolery, John C. and Crandall, Keith C., "Stochastic Network Model for Planning Scheduling" Journal of Construction Engineering, Vol 109. NO. 3, Sept 1983.

6. Carr, Robert I. and Maloney, William F., "Basic Research needs in Construction Engineering and Management", Journal of Construction Engineering Management, ASCE, Vol 109, June 1983.

7.Gupta,P.Yash,"Conceptual Aspects of Project Management - Point of No Return ",Transactions Of the American Association of Cost Engineers,F 4.1., 25 th meeting June 1981,Toronto.

8.Suhanic,George,"Change Orders Impact on Construction Cost and Schedule",Transactions of the American Association of Cost Engineers"]), F 3.1.,24th Annual meeting,July 1980,Washington D.C

9.Rad Parviz,F.,"Analysis of Working Space Congestion from Scheduling Data",Transactions of the American Association of Cost Engineers,F-41,24th Annual meeting,July 1980,Washington D.C

10.Borcherding,John D.and Sebastian,Scott J.,"Major factors Influencing Craft Productivity in Nuclear P Plant Construction",Transactions of American Association of Cost Engineers,24th Annual meeting July 1980, Washington D.C

11.Borcherding,John D.and Garner,Douglas F.,"Motivation and Productivity of Craftsmen and Foremem on Large Projects"Transactions of American Association of cost Engineers,I-2,24th Annual meeting,July 1980,Washington D.C

12.Lorenzoni,A.B.,"productivity........Everybody's Business and It can be Controlled",Cost Engineering,Vol.21,No.5,Sept/Oct 1979.

13.Carr,Robert I.,"Simulation of Construction Project Duration", Journal of Construction Division,ASCE,Vol.105,June 1979.

14.Ennokoehn,M.Selling,Kuchar,Jeffrey and Young,Randall,"Cost of Delays in Construction",Journal of Construction Division,ASCE,Vol.104,Sept.1978.

15.Gates,Marvin and Scarpa,Amerigo.,"Optimum Number of Crews",Journal of Construction Division,ASCE,Vol.104,June 1978.

16.Planning,Engineering and Constructing the Super Projects-Proceeding of the Engineering Foundation Conference,May 1978.

17.Crandall,D.C.,"Probabilistic Time Scheduling",Journal of Construction Division,ASCE,Vol.102,Sept 1976.

18.Halpin,D.W.,"Constructo - An Interactive Gaming Environment", Journal of Construction Division,ASCE,Vol.102,March 1976.

19.Carr,Robert I.et al.,"Progress Model For Construction Activity", Journal of Construction Division,ASCE,Vol.100,March 1974.

20.Grimm,Clayford T.and Wagner,Norman K.,"Weather Effects on mason Productivity",Journal of Construction Division,ASCE,Vol.100,Co3,1974.

21.Benjamin,Neal B.H.and Greenwald,Theodore W.,"Simulating Effects of Weather on Construction",Journal of Construction Division,ASCE,Vol.100,March 1974.

22.Borcherding John D.,"Motivation of Construction Craftsmen", Journal of Construction Division,ASCE,Vol.98,Sept 1972.

23.Gates,Marvin and Scarpa,Amerigo.,"Learning and Experience Curves", Journal of Construction Division,ASCE,Vol.98,march 1972.

24.Baldwin,John R.and Mantres James,M.,"Causes of Delay in Construction",Journal of Construction Division,ASCE,Vol.97,Nov.1971.

25.O'Shea,John B.,"The CPM-By-calendar Algorithm",Journal of Construction Division,ASCE,Vol.94,Oct.1968.

26.Calendar Day CPM Civil Engineering Studies,University of Illinois,1968.

27.O'Brien,"CPM in Construction Management",McGraw Hill Book Company Ltd,New york.

28.Problems and Efficiency in the management of Engineering Projects Proceeding of Symposium,University of Manchestor,April 1966.

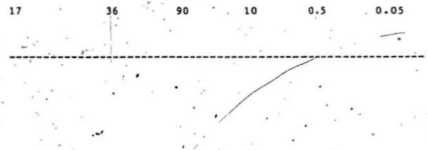
29.Van slyke, "The monte Carlo methods and PERT problem Operation Research, Vol 11, No 5, Sept 1963.

Learning curve

Total number of activities affected :17

Affected activity numbers :1,4,6,7,10,12,13,19,20,21, 22,23,25,26,30,32 & 36.

No	Acty. No.	Vol.of Work	Unit Qty.	Time for First Unit	Expected Dev.in D.C (+)
1	1	4	1	1	0.1
2	4	100	1	0.25	0.05
3	6	4000	100	0.4	0.05
4	7	2	1	1.25	0.05
5	10	40	1	0.32	0.05
6	12	100	1	0.2	0.1
7	13	20	1	0.18	0.1
8	19	1200	100	0.35	0.05
9	20	20	1	0.8	0.05
10	21	2000	100	0.35	0.05
11	22	200	10	0.8	0.05
12	23	200	10	0.8	0.05
13	25	100	10	0.6	0.05
14	26	100	10	0.6	0.05
15	30	200	10	0.8	0.05
16	32	120	10	0.6	0.05


17
36
90
10
0.5
0.05

Space congestion

Number of congested zones : 2

Available Space

Zone number	Space Available in Sq.ft.
1	400
2	600

Number of activities likely to be affected : 5

Activity	Zone	Space reqd.
6	1	300
7	1	300
25	2	400
27	2	400
28	2	400

Crew Absenteeism

Month	Range of percent Absenteeism Midweek days		Weekend/ Begin days	
	from	to	from	to
Jan	6	10	7	12
Feb	4	10	6	11
Mar	3	8	5	9
Apr	3	7	4	8
May	2	6	3	6
Jun	1	6	3	6
Jul	4	8	3	9
Aug	3	8	4	9
Sep	3	7	4	10
Oct	2	7	4	9
Nov	3	8	3	7
Dec	3	8	3	8

Number of Activities affected : 35

Note

1. Details of Impact in terms of Workday loss may be given for each activity.

2. Manpower required for tactical plan period : 25

Regulatory Requirements

Number of activities affected : 5

Numbers of activity affected : 4,8,14,16 & 17

Impact in terms of workday loss

Activity number	Range of expected workday loss Daily basis From	To	At end of acty. From	To
4	–	–	1	4
8	–	0.2	2	4
14	–	0.2	1	3
16	–	–	–	1
17	–	0.1	1	3

Design changes and Rework

Number of activities affected : 5

Numbers of activity affected : 4,11,13,25,31

Activity Number	Range of workday loss daily basis From	To	At end of acty. From	To
4	–	–	1	5
11	–	0.2	1	3
13	–	0.2	1	4
25	–	0.2	2	4
31	–	0.5	1	5

Economic activity level

Eq.relating Productivity adjustment factor with the ratio of Numbers of Workers required to available	: Y=1.15-(0.15*X)

where Y=Productivity Adjustment Factor

and X=Ratio

Value for X for Tactical plan Months

Month	Value of X
May	0.8
Jun	0.8
Jul	0.9
Aug	0.9

Labor Unrest

Number of Days expected to affected	: 12
Project day numbers that are expected to have labor unrest	: 44,45,46,47,48,66,67, 68,69,70,71,72
Activity numbers expected to have impact due to labor unrest	: 4,5,6,7,11,12,13,19, 20,21,22,23,24,26,27, 28,30,31,32,34,35,36

Note: Impact in terms of workday loss can be tabulated for each one of the activities.

Specific uncertainty variables

Number of activities likely to be affected : 8

Activity numbers expected to be affected : 4,6,8,14,15,27,33,35

Details of the expected workday loss

Acty. No.	Specific uncertainty Variable	Range of "end of activity loss From	To
4	Drill equipment Failure	-	2
6	Soil condition	1	3
8	Pole Delivery	-	2
14	Deli.Sewarage pipe.	1	2
15	Delivery Manhole	-	1
27	Material delivery	1	3
33	Compact M/c Fail	-	2
35	Conduit Drgs	-	1

```
100 CLS
110 REM "**************************************************"
120 REM "***                                            ***"
130 REM "***      PRODUF COMPUTER MODEL STEP 1          ***"
140 REM "***                                            ***"
150 REM "**************************************************"
160 LOCATE 11,20 :PRINT "CPM  SCHEDULING  PROGRAM  WITH
CALENDAR  DATE  "
170 PRINT :LOCATE  ,20 :PRINT "                      DEVELOP
ED      AT       "
180 PRINT :LOCATE  ,20 :PRINT "    FACULTY  OF     ENGI
NEERING
AND  APPLIED   SCIENCE   "
190 PRINT :LOCATE  ,20 :PRINT "      MEMORIAL     UNIVE
RSITY    OF    NEWFOUNDLAND"
200 PRINT :LOCATE  ,20 :PRINT "   ST.JOHN'S, NEWFOUND
LAND, C A N A D A - A1B 3X5 "
210 DIM F(100), T(100), E(100), L(100), A(300), C(100),
H(4),G(100),J(100),B$(100),E$(100),L$(100),G$(100),J$(100)
220 PRINT :PRINT
230 LINE INPUT "PROJECT DESCRIPTION   ";LA$
240 PRINT
250 PRINT "ARE YOU UPDATING (YES/NO)?"
260 LINE INPUT ;UD$:PRINT
270 IF UD$="YES" THEN GOSUB 6830:GOTO 290
280 UD$="NO":INPUT "INDICATE PROJECT DAY CORRESPONDING TO
END OF TACTICAL PLAN PERIOD";DN
290 CLS :LOCATE 11,25 :PRINT "DO YOU NEED A CALENDAR DATE
SCHEDULE OUTPUT  (YES/NO) ?"
300 LOCATE 15,25 :INPUT C$
310 IF C$ ="YES" GOTO 320 ELSE GOTO 370
320 CLS:LOCATE 11,20 :PRINT "HAVE YOU CREATED A CALENDAR
DATE PROJECT CALENDAR (YES/NO)? ":LOCATE 15,20 :INPUT D$
330 IF D$ = "YES" GOTO 350 ELSE GOSUB 3530
340 CLS:PRINT "THIS IS TO GENERATE TACTICAL PLAN SCHEDULE.
FEED DATA THROUGH OPTION 2"
350 CALFL$="A:"+LA$+".CFL"
360 OPEN CALFL$ AS 1 LEN = 4
370 CLS
380 LOCATE 7,20 :PRINT "INDICATE YOUR OPTION TO FEED PROJECT
ACTIVITY INPUT DATAFROM :":LOCATE 9
390 PRINT
400 LOCATE  ,20 :PRINT "1. DISKETTE (FOR STRATEGIC SCHEDULE
PRINTOUT)"
410 PRINT
420 LOCATE  ,20 :PRINT "2.INPUT DATA STATEMENTS(FOR TACTICAL
SCHEDULE PRINTOUT)"
430 PRINT
440 LOCATE  ,20 :PRINT "3. KEYBOARD "
450 PRINT
460 LOCATE  ,20 :INPUT "OPTION NUMBER ";XX
470 IF XX=1 THEN GOSUB 2990 :GOTO 620
480 IF XX=2 THEN GOSUB 3330 :GOTO 620
490 PRINT " "
```

```
500 LPRINT
510 CLS :PRINT " ENTER TOTAL NUMBER OF ACTIVITIES"
520 INPUT N
530 PRINT " "
540 FOR X=1 TO N
550 PRINT "INPUT ACTIVITY ";X;" (FROM, TO ) ";
560 INPUT F(X), T(X)
570 PRINT " DURATION IN WORKDAYS FOR ACTIVITY ";X;"
IS= ";
580 INPUT C(X)
590 LINE INPUT"ACTY.DESCRIPTION ?";B$(X)
600 NEXT X
610 CLS
620 GOSUB 1270
630 CLS:LOCATE 10,21:PRINT "PRINTING PROJECT ACTIVITY
DETAILS"
640 CLS :LPRINT TAB(15);"      P R O J E C T   A C T I
V I T Y   D E T A I L S   ":LPRINT
650 LPRINT "PROJECT      ";LA$
660 LPRINT
670 IF XX=1 THEN LPRINT TAB(23);"
STRATEGIC PLAN"
680 IF XX=2 THEN LPRINT TAB(23);"
TACTICAL PLAN"
690 LPRINT :LPRINT
700 LPRINT TAB(15) ;" ACTY    PRED    SUCC    ACTIVITY
          DURATION "
710 LPRINT TAB(15); " NO.                     DESCRI
PTION "
720 LPRINT :LPRINT
730 FOR X= 1 TO N
740 LPRINT TAB(16);X TAB(25);F(X) TAB(32);T(X) TAB(39);
B$(X) TAB(60);C(X)
750 LPRINT:LPRINT
760 NEXT X:CLS
770 IF XX=2 THEN 1500
780 PRINT :PRINT "DO YOU NEED ANY CORRECTION IN THE
PROJECT ACTIVITY INPUT DATA  (YES/NO) ?"
790 INPUT DF$:IF DF$="NO" GOTO 1500
800 IF XX = 3 THEN 840
810 PRINT "DO YOU WANT THE CHANGE TO BE EFFECTED IN
THE DISKETTE ALSO (YES/NO)?"
820 INPUT FG$:IF FG$="NO" THEN GOTO 840
830 OPEN M$ FOR OUTPUT AS #3
840 PRINT "INDICATE TOTAL NO. OF ACTIVITIES TO BE
CHANGED "
850 INPUT GG:PRINT
860 FOR Y=1 TO GG:PRINT "INDICATE ACTIVITY NUMBER
THAT NEEDS TO BE CHANGED "
870 INPUT X:PRINT
880 PRINT "INDICATE NEW PRED,SUCC EVENT NUMBERS
":INPUT F(X),T(X)
890 PRINT "GIVE NEW DESCRIPTION ":INPUT B$(X)
900 PRINT "INDICATE NEW DURATION ":INPUT C(X)
```

```
910 NEXT Y
920 PRINT "DO YOU WANT TO DELETE ANY ACTIVITY ?
(YES/NO)"
930 LINE INPUT ;DEL$
940 IF DEL$="YES" THEN 950 ELSE 1020
950 PRINT "INDICATE NUMBER OF ACTIVITIES TO BE
DELETED ":INPUT ;DEL
960 FOR X=1 TO DEL:PRINT "ACTIVITY TO BE DELETED
":INPUT DACT(X)
970 F(DACT(X))=0
980 NEXT X
990 FOR X=1 TO N
1000 IF F(X) = 0 THEN G=X :GOSUB 1170
1010 NEXT X
1020 PRINT "DO YOU WANT TO ADD ANY ACTIVITIES":LINE
INPUT ;ADD$
1030 IF ADD$="YES" THEN 1040 ELSE 1100
1040 PRINT "NUMBER OF ACTIVITIES TO BE ADDED ":INPUT
;ADD
1050 N=N+ADD
1060 FOR X=N-ADD+1 TO N
1070 PRINT "INDICATE PRED,SUCC EVENTS":INPUT F(X),T(X)
1080 PRINT "INDICATE DESCRIPTION":INPUT;B$(X)
1090 PRINT "INDICATE DURATION":INPUT C(X):NEXT X:CLS:
LOCATE 10,21:PRINT "PRINTINGPROJECT ACTIVITY DATAILS"
1100 GOSUB 1270
1110 LPRINT TAB(15) ;" ACTY.   PRED     SUCC     ACTIVITY
         DURATION "
1120 LPRINT TAB(15); " NO.                         DESCRIP
TION
1130 LPRINT :LPRINT
1140 FOR X= 1 TO N
1150 LPRINT TAB(16);X TAB(25);F(X) TAB(32);T(X) TAB(39);
B$(X) TAB(60);C(X):LPRINT :NEXT X
1160 GOTO 1220
1170 FOR Y=X+1 TO N
1180 F(Y-1)=F(Y):T(Y-1)=T(Y):B$(Y-1)=B$(Y):C(Y-1)=C(Y)
1190 NEXT Y
1200 N=N-1:X=G-1
1210 RETURN
1220 IF FG$="NO" THEN 1500
1230 WRITE #3,N
1240 FOR X = 1 TO N :WRITE #3,F(X),T(X),B$(X),C(X):NEXT X
1250 CLOSE #3
1260 GOTO 1500
1270 FOR Z =1 TO N-1
1280 J=Z
1290 FOR  X=Z+1 TO N
1300 IF F(X)>F(J) THEN 1340
1310 IF F(X)<F(J) THEN 1330
1320 IF T(X)>T(J) THEN 1340
1330 J=X
1340 NEXT  X
1350 IF J=Z THEN 1480
```

```
1360 H(1)=F(Z)
1370 H(2)=T(Z)
1380 H(3)=C(Z)
1390 H$(4)=B$(Z)
1400 F(Z)=F(J)
1410 T(Z)=T(J)
1420 C(Z)=C(J)
1430 B$(Z)=B$(J)
1440 F(J)=H(1)
1450 T(J)=H(2)
1460 C(J)=H(3)
1470 B$(J)=H$(4)
1480 NEXT  Z
1490 RETURN
1500 E(1)=1
1510 FOR  X=1 TO N
1520 E(X)=E(X)+C(X)
1530 IF X=N THEN 1610
1540 FOR  D=X+1 TO N
1550 IF F(D)=F(1) THEN E(D)=1
1560 IF T(X) <>F(D) THEN 1590
1570 IF E(D)>E(X) THEN 1590
1580 E(D) =E(X)
1590 NEXT  D
1600 NEXT  X
1610 P=0
1620 FOR X=1 TO N
1630 IF P>E(X) THEN 1650
1640 P=E(X)
1650 NEXT  X
1660 FOR  X=1 TO N
1670 L(X)=P
1680 NEXT  X
1690 FOR Z=1 TO N
1700 X=N-Z+1
1710 FOR  D=1 TO N-Z
1720 IF F(X) <>T(D) THEN 1750
1730  IF L(X)-C(X)>L(D) THEN 1750
1740 L(D)=L(X)-C(X)
1750 NEXT  D
1760 NEXT  Z
1770 FOR  X=1 TO N
1780 A(X)=L(X)-E(X)
1790 NEXT X
1800 C1=L(N)-1:EN=C1:DN=EN-ST
1810 FOR  X=1 TO N
1820 E(X)=E(X)-C(X)
1830 L(X)=L(X)-C(X)
1840 G(X)=E(X)+C(X)-1
1850 J(X)=L(X)+C(X)-1
1860 NEXT  X
1870 REM
1880 IF C$ ="NO" THEN 1950
1890 PRINT " "
```

```
1900 CLS:LOCATE 10,20 :PRINT "WHAT TYPE OF
SCHEDULE DO YOU WANT ?":LOCATE 12
1910 PRINT :LOCATE  ,20 :PRINT "1.CALENDAR DATE "
1920 PRINT :LOCATE  ,20 :PRINT "2.WORK DAY NUMBER "
1930 PRINT :LOCATE  ,20 :INPUT A$
1940 PRINT " "
1950 CLS:LOCATE 5,20 :PRINT  "---------------PROJECT
SCHEDULE STATUS REPORT-------------------"
1960 LPRINT "-----------------PROJECT SCHEDULE STATUS
 REPORT--------------"
1970 PRINT
1980 LPRINT
1990 LPRINT
2000 LPRINT
2010 IF XX=1 THEN LPRINT "
STRATEGIC SCHEDULE"
2020 IF XX=2 THEN LPRINT "
TACTICAL SCHEDULE"
2030 PRINT "PROJECT----";LA$
2040 LPRINT "PROJECT----";LA$
2050 PRINT  " " :LPRINT
2060 IF C$="NO" THEN 2090
2070 IF A$="2" THEN 2090
2080 IF A$="1" THEN 2110
2090 PRINT "
        WORKDAY REPORT"
2100 LPRINT "
         WORKDAY REPORT":GOTO 2140
2110 PRINT "
    CALENDAR DATE REPORT"
2120 LPRINT "
     CALENDAR DATE REPORT"
2130 PRINT
2140 LPRINT:LPRINT
2150 IF C$ ="NO" THEN 2160
2160 GOSUB 2790
2170 IF C$="NO" OR A$="2" GOTO 2470
2180 IF A$ ="1" GOTO 2190
2190 FOR X = 1 TO N
2200 IF G(X)=0 THEN 2250
2210 C=E(X):GOSUB 2860:E$(X) = DTE$
2220 C=L(X):GOSUB 2860:L$(X)= DTE$
2230 C= G(X):GOSUB 2860:G$(X)= DTE$
2240 C=J(X):GOSUB 2860:J$(X)= DTE$
2250 NEXT X:IF XX=1 THEN 2330
2260 M$="OP1":OPEN M$ FOR OUTPUT AS 2:IF ST=0 THE
N ST=1
2270 WRITE #2,DN,N,NN,ST,EN
2280 FOR X = 1 TO N
2290 WRITE #2,F(X),T(X),B$(X),C(X)
2300 NEXT X:FOR X=1 TO N:WRITE #2,E(X),L(X),G(X),
J(X),A(X):NEXT X
2310 FOR X=1 TO NN
2320 WRITE #2,NA(X):NEXT X:CLOSE #2
```

```
2330 FOR X = 1 TO N
2340 IF G(X)=0 THEN 2450
2350 PRINT F(X);TAB(6);T(X);TAB(12); B$(X);TAB(27)
;C(X);TAB(33);E$(X);TAB(43);L$(X);TAB(53);G$(X);TAB(63);
J$(X);TAB(73);A(X);TAB(78);
2360 LPRINT F(X);TAB(6);T(X);TAB(12); B$(X);TAB(27);C(X)
;TAB(33);E$(X);TAB(43);L$(X);TAB(53);G$(X);TAB(63);J$(X)
;TAB(74);A(X);TAB(78);
2370 IF A(X) =0 THEN 2400
2380 PRINT :LPRINT: PRINT :LPRINT
2390 GOTO 2430
2400 PRINT "*"
2410 LPRINT " * "
2420 PRINT
2430 M = M + 1
2440 PRINT:LPRINT
2450 NEXT X
2460 GOTO 2590
2470 FOR X = 1 TO N
2480 IF G(X)=0 THEN 2580
2490 PRINT F(X);TAB(6);T(X);TAB(12); B$(X);TAB(28);C(X);
TAB(35);E(X);TAB(45);L(X);TAB(55);G(X);TAB(65);J(X);
TAB(72);A(X);TAB(79);
2500 LPRINT F(X);TAB(6);T(X);TAB(12); B$(X);TAB(28);
C(X);TAB(35);E(X);TAB(45);L(X);TAB(55);G(X);TAB(65);
J(X);TAB(73);A(X);TAB(79);
2510 IF A(X)=0 THEN 2550
2520 PRINT:PRINT
2530 LPRINT:LPRINT
2540 GOTO 2570
2550 PRINT"* "
2560 LPRINT "* "
2570 PRINT:LPRINT
2580 NEXT X
2590 PRINT " * - INDICATES CRITICAL ACTIVITY "
2600 LPRINT " * - INDICATES CRITICAL ACTIVITY "
2610 LPRINT:PRINT
2620 PRINT "PROJECT DURATION IS " ; C1
2630 LPRINT
2640 LPRINT "PROJECT DURATION IS ";C1;"DAYS"
2650 PRINT " "
2660 CLS :LOCATE 10,20 :PRINT "INDICATE YOUR CHOICE "
2670 PRINT :LOCATE ,20 :PRINT "1.ANOTHER PRINTOUT
2680 PRINT :LOCATE ,20 :PRINT "2.EXIT
2690 PRINT :LOCATE ,20 :INPUT ZZ
2700 IF ZZ =1 GOTO 1880
2710 CLOSE 1
2720 IF XX=1 THEN GOTO 340
2730 IF UD$="YES" THEN 2740 ELSE 6960
2740 PRINT "IS THERE ANY CHANGE IN LOGIC AND/OR IMPACT
 CONSIDERED IN THE PRECEDING TACTICAL PLAN ?(YES/NO)"
2750 LINE INPUT LO$
2760 IF LO$="YES" THEN 2770 ELSE 9980
2770 PRINT "CONSIDER NEW TACTICAL PLAN AND FEED ALL NEW
```

```
DATA "
2780 GOTO 6960
2790 REM SUBROUTINE FOR TITLE DESCRIPTION
2800 PRINT "PRED SUCC  ACTIVITY         DURA          START
            FINISH"
2810 LPRINT"PRED SUCC  ACTIVITY         DURA          START
            FINISH"
2820 PRINT"EVE  EVE   DESERIPTION      TION   EARLY       L
ATE    EARLY       LATE    TF"
2830 LPRINT"EVE  EVE   DESCRIPTON      TION   EARLY       L
ATE.      EARLY      LATE    TF"
2840 PRINT : LPRINT
2850 RETURN
2860 Z = 1:C=C+ST
2870 FIELD Z,2 AS MD$, 2 AS YR$
2880 GET Z,C
2890 DT$=STR$(CVI(MD$))
2900 M =.INT (CVI(MD$)/100)
2910 D$=RIGHT$(DT$,2)
2920 YR=CVI(YR$)
2930 P$ = D$
2940 Q$ =STR$(YR)
2950 K$= RIGHT$(Q$,2)
2960 J$ = STR$(M)
2970 DTE$ = P$+"/"+J$+"/"+K$
2980 RETURN
2990 REM SUBROUTINE TO READ PROJECT ACTIVITY INPUT DATA
FROM DISKETTE
3000 CLS:LOCATE 10,20 :PRINT "HAVE YOU ALREADY LOADED T
HE PROJECT ACTIVITY INPUT DATA IN THE DISKETTE(Y/N)?"
3010 LOCATE 12 ,20 :INPUT YY$
3020 IF YY$="Y" THEN 3220
3030 M$="DAFI"
3040 OPEN M$ FOR OUTPUT AS 2
3050 PRINT " "
3060 PRINT
3070 PRINT " ENTER TOTAL NUMBER OF ACTIVITIES"
3080 INPUT N
3090 PRINT " "
3100 FOR X=1 TO N
3110 PRINT "INPUT ACTIVITY  ";X;" (FROM, TO ) ";
3120 INPUT F(X), T(X)
3130 PRINT " DURATION FOR ACTIVITY  ";X;" IS= ";
3140 INPUT C(X)
3150 LINE INPUT"ACTY.DESCRIPTION ?";B$(X)
3160 NEXT X
3170 GOSUB 1270
3180 WRITE #2,N
3190 FOR X= 1 TO N :WRITE #2,F(X),T(X),B$(X),C(X) :NEXT
 X
3200 CLOSE #2
3210 RETURN
3220 RR$="DAFI"
3230 M$="A:"+RR$
```

```
3240 OPEN M$ FOR INPUT AS 2
3250 INPUT #2,N
3260 WRITE #2,N
3270 FOR X=1 TO N
3280 INPUT #2,F(X),T(X),B$(X),C(X)
3290 WRITE #2,F(X),T(X),B$(X),C(X)
3300 NEXT X
3310 CLOSE #2
3320 RETURN
3330 REM
3340 REM     1. THE FIRST DATALINE INDICATES ONLY THE
TOTAL NO. OF ACTIVITY
3350 REM
3360 REM       2\FROM SECOND DATALINE ONWARDS,EACH DATAL
INE GIVES PROJECT
3370 REM
3380 REM          DETAILS FOR THREE ACTIVITIES IN THE FOL
LOWING SEQUENCE
3390 REM
3400 REM       a)PREC. ACTY.NUMBER b)SUCC.ACTY.NUMBER c
)DESCRIPTION d)DURATION
3410 REM     3.DO CHANGES BY MODIFING N VALUE AND ACTIV
ITY DETAILS CORRECTLY
3420 READ N
3430 DATA 36
3440 FOR X = 1 TO N
3450 READ  F(X),T(X),B$(X),C(X)
3460 NEXT X
3470 DATA 0,1,CLEAR SITE,3,1,2,SURVEY&L.O,2,2,3,ROUGH
GRADE,2,3,4,DRILL WELL,15,3,6,FOUND.WELL,4,3,9,EXCA.FO
R SEWAR.,10,3,10,EXCA.MANHO,1,3,12,O.H.POLE,6
3480 DATA 4,5,INSTALL W.P,2,5,8,U.G.W.P,8,6,7,ERECT W.
T,10,7,8,TANK PIPE,10,8,13,CONNECT PIPING,2,9,11,INSTA
LL SEWAR,5,10,11,INSTALL M/H,5,11,12,INSTALL ELEC.DUCT,3
3490 DATA 12,13,PULLIN P/FEED,5,13,14,BLDG L/O,1,13,23,
EXCA.FOR OFF,3,14,15,DRIVE &POUR PILE,10,15,16,EXCA.PLA
W/H,5,16,17,POUR PILE CAP,5,17,18,FORM AND POUR,10
3500 DATA 18,19,BACKFILL,3,18,21,FORM & POUR R/L,5,18,2
2,FORM & POUR T/L,5,19,20,U/S PLUMB,5,20,22,U/S CONDUIT
,5,21,22,DUMMY,0,22,29,FORM & POUR,10
3510 DATA 23,24,SPREAD PLOT,3,24,25,FORM&POUR,6,25,26,
B/F&COMPACT,1,26,27,U/S PLUMB,3,27,28,U/S CONDUIT,3,28
,29,FORM&POUR,3
3520 RETURN
3530 CLS
3540 READ N
3550 FOR X=1 TO N:READ F(X),T(X),B$(X),C(X)
3560 F(X)=T(X)=C(X)=0:B$(X)="O":NEXT X:N=O
3570 REM SUB ROUTINE TO GENERATE PROJECT CALENDAR
3580 LOCATE 8,26
3590 INPUT "ENTER START DATE OF PROJECT";SYR$
3600 SYR=VAL(RIGHT$(SYR$,4))
3610 SM=VAL(LEFT$(SYR$,2))
3620 SD=VAL(MID$(SYR$,4,2))
```

```
3630 S=-5:FOR Y=1 TO SM:S=S+6:NEXT Y
3640 IF SYR<1981 THEN CLS:PRINT "INVALID START DATE...
...";SYR$:GOTO 3640
3650 LOCATE 10,26
3660 INPUT"ENTER FINISH DATE OF PROJECT";FYR$
3670 FM=VAL(LEFT$(FYR$,2))
3680 FD=VAL(MID$(FYR$,4,2))
3690 FYR=VAL(RIGHT$(FYR$,4))
3700 F=-5:FOR Y=1 TO FM:F=F+6:NEXT Y
3710 IF FYR<SYR THEN CLS:PRINT "INVALID FINISH DATE...
...";FYR$:GOTO 3640
3720 N=FYR-SYR+1
3730 IF N<0 OR N>4 THEN PRINT "INVALID NUMBER OF YEARS
, TRY AGAIN" : GOTO 3660
3740 CLS : LOCATE 10,21
3750 LO$ = "EXECUTING......PLEASE WAIT FOR NEXT PROMPT
3760 PRINT LO$
3770 DIM DDT%(7,72,N),MNL%(12),MNAME$(67),DNAME$(7),H$(200)
3780 REM
3790 REM
3800 REM ESTABLISHES ON WHAT DAY YEAR BEGINS
3810 YR=1981:X=5:L=0
3820 IF SYR=YR GOTO 3940
3830 YR=YR+1:L=L+1
3840 IF L=4 THEN L=0:X=X+1
3850 GOSUB 3910
3860 GOTO 3820
3870 REM
3880 REM
3890 REM
3900 REM SUBROUTINE TO INCREMENT X,Y,AND B
3910 X=X+1
3920 IF X>7 THEN X=1:Y=Y+1:B=B+1
3930 RETURN
3940 MNAME$(1) = " JANUARY " : MNAME$(7) = " FEBRUARY"
3950 MNAME$(13) = "  MARCH  " : MNAME$(19) = "  APRIL  "
3960 MNAME$(25) = "   MAY   " : MNAME$(31) = "   JUNE  "
3970 MNAME$(37) = "  JULY   " : MNAME$(43) = " AUGUST  "
3980 MNAME$(49) = "SEPTEMBER" : MNAME$(55) = " OCTOBER "
3990 MNAME$(61) = " NOVEMBER" : MNAME$(67) = " DECEMBER"
4000 DNAME$(1) = " SUN "
4010 DNAME$(2) = " MON "
4020 DNAME$(3) = " TUE "
4030 DNAME$(4) = " WED "
4040 DNAME$(5) = " THU "
4050 DNAME$(6) = " FRI "
4060 DNAME$(7)=" SAT "
4070 REM
4080 REM
4090 REM PROGRAM TO CREATE CALENDAR
4100 FOR I=1 TO N
4110 Y=1
4120 FOR A=1 TO 12
4130 B=0
```

```
4140 READ MNL%(A)
4150 DATA 31,28,31,30,31,30,31,31,30,31,30,31,
4160 IF L=3 THEN MNL%(2)=29
4170 FOR D=1 TO MNL%(A)
4180 DDT%(X,Y,I)=D
4190 REM ESTABLISH START AND FINISH OF CALENDAR
4200 IF I=1 AND Y<S THEN DDT%(X,Y,I)=0
4210 IF I=1 AND Y<=S+5 AND DDT%(X,Y,I)<SD THEN DDT%(X,
Y,I)=0
4220 IF I=N AND Y>=F AND DDT%(X,Y,I)>FD THEN DDT%(X,Y,
I)=0
4230 IF I=N AND Y>=F+5 THEN DDT%(X,Y,I)=0
4240 GOSUB 3910
4250 REM
4260 NEXT D
4270 B=6-B:Y=Y+B
4280 NEXT A
4290 RESTORE
4300 READ M:FOR O=1 TO M:READ F(O),T(O),B$(O),C(O):NEX
T O:O=0:M=0
4310 L=L+1
4320 NEXT I
4330 REM
4340 REM
4350 CLS
4360 REM PROGRAM TO DELETE WEEKDAYS
4370 LOCATE 8
4380 PRINT "          SUN       MON       TUE       WED
      THU       FRI       SAT"
4390 PRINT
4400 PRINT "          1         2         3         4
      5         6         7"
4410 LOCATE 12
4420 PRINT "ENTER NUMBERS CORRESPONDING TO DAYS OF WEEK
 NORMALLY NOT CONSIDERED AS WORKDAYS"
4430 PRINT "                              .SEPARATE B
Y COMMAS."
4440 LOCATE 15,35
4450 L1$ = "YOU HAVE CHOSEN A "
4460 L2$ = " DAY WEEK."
4470 L3$ = "THE ABOVE DAYS ARE CONSIDERED AS NONWORKING
 DAYS."
4480 L4$ = "IS THIS CORRECT (Y/N) ?"
4490 LINE INPUT ;DAY$
4500 CLS : B = 0 : FOR L = 1 TO 14 STEP 2 : B = B + 1
4510 D = VAL (MID$ (DAY$,L,1)) : IF L = 1 AND D = 0 THE
N LOCATE 10,27 : PRINT L1$ + "7" + L2$ : GOTO 4550 ELSE
 IF D = 0 GOTO 4530
4520 LOCATE 2 + L,39 : PRINT DNAME$ (D) : NEXT L
4530 LOCATE 10,26 : PRINT L1$;8-B;L2$
4540 LOCATE 11,17 : PRINT L3$
4550 LOCATE 13,30 : PRINT L4$
4560 A$=INKEY$:IF A$="Y"OR A$="y"GOTO 4570 ELSE IF A$="
N" OR A$="n" GOTO 4350 ELSE 4560
```

```
4570 CLS : FOR L=1 TO 14 STEP 2
4580 DY = VAL(MID$(DAY$,L,1))
4590 IF DY=0 GOTO 4680
4600 FOR I=1 TO N
4610 FOR Y=1 TO 72
4620 DDT%(DY,Y,I)=0
4630 NEXT Y
4640 NEXT I
4650 NEXT L
4660 REM
4670 REM
4680 B = 1
4690 CLS : B = B - 1
4700 REM TO DELETE HOLIDAYS AND ESTABLISH WORKDAY
COUNTER
4710 LOCATE 4 : PRINT "ENTER MONTH DATE AND YEAR FOR
 HOLIDAYS IF APPLICABLE.
4720 PRINT
4730 PRINT "ENTER E TO EXIT AFTER ALL HOLIDAYS HAVE
BEEN ENTERED
4740 PRINT
4750 LOCATE , 35 : B = B + 1
4760 INPUT;H$(B) : PRINT
4770 IF H$(B) = "E"OR H$(B)="e" THEN CLS : LOCATE 2,20
 : PRINT "THESE ARE THE HOLIDAYS YOU HAVE ENTERED" :
GOSUB 4920 : GOTO 4970
4780 GOTO 4750
4790 FOR C = 1 TO B - 1
4800 HM=VAL(LEFT$(H$(C),2))
4810 HD=VAL(MID$(H$(C),4,2))
4820 HY=VAL(RIGHT$(H$(C),4))
4830 REM
4840 REM TO DELETE DAY IN CERTAIN YEAR
4850 M=-5:FOR Y=1 TO HM:M=M+6:NEXT Y
4860 IF HY>1980 THEN I=HY-SYR+1:GOSUB 5080:GOTO 4910
4870 REM TO DELETE DAYS IN ALL YEARS
4880 FOR I=1 TO N
4890 GOSUB 5080
4900 NEXT I
4910 NEXT C : GOTO 5140
4920 PRINT
4930 FOR C = 1 TO B -1 : PRINT USING "##";C;
4940 PRINT ". ";
4950 PRINT USING "@            @";H$(C);
4960 NEXT C : PRINT : X = CSRLIN : LOCATE X + 2 :
RETURN
4970 LOCATE X + 2,25 : PRINT " ARE THESE DATES COR
RECT (Y/N)"
4980 A$=INKEY$:IF A$="Y"OR A$="y"THEN CLS : LOCATE
 10,21 : PRINT LO$ : GOTO 4790 ELSE IF A$ = "N" OR
 A$ = "n" GOTO 4990 ELSE 4980
4990 LOCATE X + 5,26 : PRINT "WHAT WOULD YOU LIKE
TO DO  ?" : LOCATE X + 7
5000 LOCATE ,20 : PRINT "1.    CHANGE SOME OF THE
```

```
HOLIDAY DATES?
5010 LOCATE ,20 : PRINT "2.    ADD SOME MORE HOLID
AYS ?"
5020 LOCATE ,20 : PRINT "3.    DELETE SOME OF THE
HOLIDAYS ?"
5030 LOCATE ,20 : PRINT "4.    EXIT ?"
5040 A$=INKEY$:IF A$="1" GOTO 5060 ELSE IF A$="2"
GOTO 4690 ELSE IF A$ = "3" GOTO 5050 ELSE IF A$ =
 "4" GOTO 4770 ELSE 5040
5050 CLS : GOSUB 4920 : LOCATE X + 2 : INPUT "ENT
ER THE NUMBER OF THE DATE YOU WISH TO DELETE";K :
 H$(K) = "     " : GOTO 4770
5060 CLS : GOSUB 4920 : LOCATE X + 2 : INPUT " EN
TER THE NUMBER OF THE DATE YOU WISH TO CHANGE AND
 THE NEW DATE" ;K, H$(K):GOTO 4770
5070 REM SUBROUTINE TO DELETE DAY OF MONTH
5080 FOR E=M TO M+5
5090 FOR X=1 TO 7
5100 IF DDT%(X,E,I) = HD THEN DDT%(X,E,I) = 0 :RE
TURN
5110 NEXT X
5120 NEXT E
5130 RETURN
5140 REM
5150 C = 0
5160 FOR I=1 TO N
5170 FOR Y=1 TO 71
5180 IF Y=1 THEN DDT%(0,Y,I)=C
5190 IF DDT%(0,Y,I)=DDT%(0,72,I-1) THEN DDT%(0,72
,I-1)=0
5200 B=C
5210 FOR X=1 TO 7
5220 IF I=1 AND Y<S+2 AND DDT%(X,Y,I)=SD THEN DDT
%(0,Y,I)=1
5230 IF DDT%(X,Y,I)<>0 THEN C=C+1
5240 NEXT X
5250 DDT%(0,Y+1,I)=C+1
5260 IF B=C THEN DDT%(0,Y,I)=0
5270 NEXT Y
5280 C=C+1
5290 NEXT I
5300 REM
5310 REM
5320 CLS
5330 LOCATE 6,26 : PRINT"WHAT WOULD YOU LIKE ?":L
OCATE 8
5340 LOCATE ,20 : PRINT "1.    SCREEN PRINTOUT OF
 CALENDAR ?"
5350 LOCATE ,20 : PRINT "2.    HARDCOPY PRINTOUT
OF CALENDAR?"
5360 LOCATE ,20 : PRINT "3.    CREATION OF A WORK
DAY CALENDAR FILE?"
5370 A$=INKEY$:IF A$="1" GOTO 5390 ELSE IF A$="2"
GOTO 5810 ELSE IF A$ = "3" GOTO 6260 ELSE GOTO 5370
```

```
5380 STOP
5390 REM PROGRAM FOR CALENDAR PRINTOUT ON SCREEN
5400 FOR I=1 TO N
5410 X=1:Y=1:E=-11:F=-6
5420 CLS
5430 PRINT "
";SYR-1+I
5440 PRINT
5450 FOR K=1 TO 67 STEP 12
5460 PRINT "                              "MNAME$(K);
5470 PRINT "                                        "MNAME$(
K+6)
5480 PRINT
5490 PRINT "            #      SUN MON TUE WED THU FRI S
AT       #      SUN MON TUE WED THU FRI SAT"
5500 PRINT
5510 E=E+12:F=F+12
5520 FOR Y=E TO F
5530 FOR X=1 TO 7
5540 B=Y
5550 IF X=1 THEN GOSUB 5710
5560 IF DDT%(X,Y,I)=0 THEN PRINT "    ";:GOTO 5580
5570 PRINT USING "####";DDT%(X,Y,I);
5580 NEXT X
5590 FOR X=1 TO 7
5600 B=Y+6
5610 IF X=1 THEN GOSUB 5710
5620 IF DDT%(X,Y+6,I)=0 THEN PRINT "    ";:GOTO 5640
5630 PRINT USING "####";DDT%(X,Y+6,I);
5640 NEXT X
5650 PRINT "  ";
5660 NEXT Y
5670 Z = CSRLIN : IF Z >= 18 THEN  LOCATE 23,20 :
 PRINT "PRESS ENTER KEY TO CONTINUE OR E TO EXIT"
: GOTO 5760
5680 NEXT K
5690 NEXT I
5700 GOTO 5780
5710 IF DDT%(0,B,I)=0 THEN PRINT "          ";:GO
TO 5750
5720 PRINT "    (";
5730 PRINT USING "####";DDT%(0,B,I);
5740 PRINT ")";
5750 RETURN
5760 A$=INKEY$:IF A$="E"OR A$="e"GOTO 5780 ELSE IF
 A$=CHR$(13) GOTO 5770 ELSE 5760
5770 CLS : GOTO 5680
5780 GOTO 5320
5790 REM
5800 REM
5810 REM PROGRAM ROR HARDCOPY CALENDAR PRINTOUT
5820 T$ = "                          P R O J E C T
C A L E N D A R            "
5830 FOR I=1 TO N
```

```
5840 X=1:Y=1:E=-11:F=-6
5850 LPRINT T$
5860 LPRINT:LPRINT
5870 LPRINT "
";SYR-1+I
5880 FOR K=1 TO 67 STEP 12
5890 LPRINT "                              "MNAME$(K);
5900 LPRINT "                                      "MNAME$
(K+6)
5910 LPRINT
5920 LPRINT "         #      SUN MON TUE WED THU FRI
SAT        #       SUN MON TUE WED THU FRI SAT"
5930 LPRINT
5940 E=E+12:F=F+12
5950 FOR Y=E TO F
5960 FOR X=1 TO 7
5970 B=Y
5980 IF X=1 THEN GOSUB 6170
5990 IF DDT%(X,Y,I)=0 THEN LPRINT "    ";:GOTO 6010
6000 LPRINT USING "####";DDT%(X,Y,I);
6010 NEXT X
6020 FOR X=1 TO 7
6030 B=Y+6
6040 IF X=1 THEN GOSUB 6170
6050 IF DDT%(X,Y+6,I)=0 THEN LPRINT "    ";:GOTO
6070
6060 LPRINT USING "####";DDT%(X,Y+6,I);
6070 NEXT X
6080 LPRINT "  ";
6090 NEXT Y
6100 NEXT K
6110 LPRINT
6120 LPRINT
6130 LPRINT
6140 LPRINT
6150 NEXT I
6160 GOTO 6220
6170 IF DDT%(0,B,I)=0 THEN LPRINT "           ";:
GOTO 6210
6180 LPRINT "     (";
6190 LPRINT USING "####";DDT%(0,B,I);
6200 LPRINT ")";
6210 RETURN
6220 GOTO 5320
6230 REM
6240 REM
6250 REM PROGRAM TO CREATE RANDOM FILE
6260 CLS
6270 Z=1:W=2
6280 LOCATE 10
6290 CLS : LOCATE 10,29
6300 PRINT "CREATING FILE ON DISC"
6310 CALFL$ = "A:" + LA$ + ".CFL"
6320 OPEN CALFL$ AS #3 LEN = 4
```

```
6330 FIELD #3,2 AS MD$, 2 AS YR$
6340 C = 0
6350 FOR I = 1 TO N
6360 B = 1 : J = 0
6370 FOR Y = 1 TO 72
6380 IF Y = B THEN B = B + 6 : J = J + 100
6390 FOR X = 1 TO 7
6400 IF DDT%(X,Y,I) <> 0 THEN GOSUB 6480:GOTO 6430
6410 IF C=0 THEN 6430
6420 IF C>0 THEN GOSUB 6670
6430 NEXT X
6440 NEXT Y
6450 RESTORE
6460 NEXT I
6470 GOTO,6550
6480 C = C + 1
6490 IF X=W THEN GOSUB 6710
6500 IF X=6 THEN GOSUB 6740
6510 RSET MD$ = MKI$(DDT%(X,Y,I) + J):DT$=STR$(CV
I(MD$))
6520 RSET YR$ = MKI$(SYR + I - 1):YR=CVI(YR$)
6530 PUT #3,C
6540 RETURN
6550 CLS : LOCATE 10,34
6560 PRINT "FILE CREATED"
6570 CLOSE #3
6580 FOR X=1 TO Z
6590 NEXT X
6600 H$="OP9"
6610 OPEN H$ FOR OUTPUT AS #9
6620 WRITE #9,Z
6630 FOR S=1 TO Z
6640 WRITE #9,A(S):NEXT S
6650 CLOSE #9
6660 RETURN
6670 IF X= 2 THEN W=W+1:GOSUB 6800
6680 IF X = 6 THEN GOSUB 6760 ELSE 6690
6690 IF W = 3 AND X=7 THEN W=2
6700 RETURN
6710 IF X=3 AND W=3 THEN 6730
6720 A(Z)=C:Z=Z+1:W=2
6730 RETURN
6740 A(Z)=C:Z=Z+1
6750 RETURN
6760 IF VAL(DT$)=630 OR 731 THEN 6790
6770 A(Z)=C-1
6780 Z=Z+1
6790 RETURN
6800 IF VAL(DT$)=630 OR 731 THEN 6820 ELSE 6810
6810 RETURN
6820 RETURN
6830 PRINT "HAVE YOU CORRECTED DATA STATEMENTS SUIT
ABLY ? (NOTE: IF LOGIC CHANGEAND/OR IMPACT CHANGE I
S ENVISAGED,THE NEW TACTICAL PLAN MUST BE MADE)"
```

```
6840 LINE INPUT ;DA$
6850 IF DA$="YES" THEN 6870
6860 PRINT "THE PROGRAM IS TERMINATED.PLEASE CALL F
OR DATA STATEMENTS 2850-2950 AND CORRECT THEM .":END
6870 PRINT "INDICATE PROJECT DAY CORRESPONDING TO T
HE START DAY OF THE CURRENT TACTICAL PLAN PERIOD"
6880 INPUT ;ST
6890 PRINT "INDICATE TOTAL NO.OF NEW ACTIVITIES"
6900 INPUT ;NN
6910 PRINT "INDICATE NEW ACTIVITY NO.ONE BY ONE"
6920 FOR X=1 TO NN
6930 PRINT "ACTIVITY NUMBER":INPUT ;NA(X)
6940 NEXT X
6950 RETURN
6960 SCREEN 2
6970 CLEAR
6980 CLS
6990 M$="OP1"
7000 DIM V(50),U(50),TS(50),DV(50),F(50),T(50),B$(50),
C(50),A(50),ACT(50)
7010 OPEN M$ FOR INPUT AS #2
7020 INPUT #2,DN,N,NN,ST,EN
7030 FOR X=1 TO N:INPUT #2,F(X),T(X),B$(X),C(X)
7040 NEXT X:CLOSE #2:CLS
7050 I=1
7060 PRINT :PRINT "HOW MANY ACTIVITIES ARE EXPECTED TO
 HAVE L.C.IMPACT ?"
7070 PRINT :INPUT ;LC
7080 FOR X=1 TO LC :PRINT
7090 PRINT "INDICATE ACTIVITY NUMBER "
7100 PRINT :INPUT ;ACT(X)
7110 NEXT X:CLS
7120 X=1
7130 PRINT "ACTY  ACTY                   EST.          VOL
.OF    UNIT   TIME FOR  EXPECT.
7140 PRINT "NO.   DESCRIPTION            DUR           WOR
K      QTY    FIRST UN. D.C VAR.
7150 LINE (45,1)-(45,199)
7160 LINE (190,1)-(190,199):LINE(240,1)-(240,199):LINE
(300,1)-(300,199)
7170 LINE(370,1)-(370,199):LINE(440,1)-(440,199):LINE (
520,1)-(520,199):LINE (590,1)-(590,199)
7180 FOR L=20 TO 199 STEP 16
7190 LINE (1,L)-(590,L)
7200 NEXT L
7210 FOR Q=4 TO 22 STEP 2
7220 LOCATE Q,2:PRINT ACT(X):LOCATE Q,8:PRINT B$(ACT(X)
):LOCATE Q,25:  PRINT C(ACT(X))
7230 LOCATE Q,41:INPUT ;V(ACT(X)):LOCATE Q,49:INPUT;U(A
CT(X)):LOCATE Q,57:INPUT;TS(ACT(X)):LOCATE Q,67:INPUT D
V(ACT(X))
7240 X=X+1:IF X = LC+1 THEN GOTO 7270
7250 NEXT Q:CLS
7260 IF X>LC+1 THEN GOTO 7270  ELSE GOTO 7130
```

```
7270 CLS
7280 M$="OP2":OPEN M$ FOR OUTPUT AS #3:WRITE #3,LC:FOR
X=1 TO LC:WRITE #3,ACT(X):NEXT X
7290 FOR X=1 TO N
7300 WRITE #3,V(X),U(X),TS(X),DV(X)
7310 NEXT X
7320 CLOSE #3
7330 CLEAR
7340 DIM T(50),F(50),C(50),F$(100),RN(100),T1(50),T2(50
),T3(50),T4(50),ACT(100),B$(50)
7350 SCREEN 2
7360 PRINT "HOW MANY TACTICAL PLAN ACTIVITIES ARE AFFEC
TED BY WEATHER CONDITIONS"
7370 INPUT WI
7380 PRINT "ENTER ACTIVITY NOS.THAT ARE LIKELY TO BE AF
FECTED BY WEATHER"
7390 FOR X=1 TO WI
7400 INPUT "ACTIVITY NUMBER ";ACT(X):PRINT
7410 NEXT X
7420 X=1
7430 CLS
7440 REM TO CALCULATE THE IMPACT OF THE WEATHER
7450 PRINT "ACTY  ACTY                    T E M P IN DEG.F
      SNOW  RA     "
7460 PRINT "NO.   DESCRIPTION
       >10  >5"
7470 PRINT "                              <0    <5    <15
 >25        C M   M M  "
7480 LINE (45,1)-(45,199):LINE (175,1)-(175,199)
7490 LINE (195,1)-(195,199):LINE(240,10)-(240,199):LINE
 (290,10)-(290,199):LINE (340,10)-(340,199)
7500 LINE(390,1)-(390,199):LINE(435,1)-(435,199):LINE(4
82,1)-(482,199):LINE (540,1)-(540,199):LINE (590,1)-(59
0,199)
7510 FOR L=36 TO 199 STEP 16
7520 LINE (1,L)-(590,L)
7530 NEXT L
7540 FOR Q=6 TO 22 STEP 2
7550 LOCATE Q,2:PRINT X:LOCATE Q,7:PRINT B$(X)
7560 LOCATE Q,26:INPUT ;T1(ACT(X)):LOCATE Q,32:INPUT ;T
2(ACT(X)):LOCATE Q,38:INPUT ;T3(ACT(X)):LOCATE Q,44:INP
UT;T4(ACT(X)):LOCATE Q,56:INPUT T(ACT(X)):LOCATE Q,63:I
NPUT ;C(ACT(X))
7570 X=X+1:IF X > WI THEN 7610
7580 NEXT Q
7590 IF X >WI THEN 7610 ELSE 7600
7600 CLS:GOTO 7440
7610 CLS
7620 H$="OP5"
7630 OPEN H$ FOR OUTPUT AS #7
7640 WRITE #7,WI:FOR X=1 TO WI:WRITE #7,ACT(X):NEXT X
7650 FOR X= 1 TO WI:WRITE #7,T1(ACT(X)),T2(ACT(X)),T3(A
CT(X)),T4(ACT(X)),T(ACT(X)),C(ACT(X))
7660 NEXT X
```

```
7670 CLOSE #7
7680 CLEAR:DIM SP(20),SSP(20),ACT(50),ZN(50),SPR(50)
7690 PRINT "INDICATE TOTAL NUMBER OF ZONES OF THE PROJE
CT THAT ARE LIKELY TO HAVE SPACE CONSTRAINT."
7700 INPUT ;Z:CLS
7710 PRINT "        ZONE NUMBER                SPACE AV
AILABLE "
7720 Q=5:PRINT
7730 FOR X=1 TO Z
7740 LOCATE Q,20:PRINT X:LOCATE Q,40:INPUT ;SP(X)
7750 SSP(X)=SP(X)
7760 Q=Q+2:IF Q=23 THEN CLS:GOSUB 7950
7770 NEXT X
7780 PRINT "INDICATE TOTAL NUMBER OF TACTICAL PLAN ACTI
VITIES THAT ARE LIKELY TO BE AFFECTED BY SPACE
 CONGESTION"
7790 INPUT SC:CLS
7800 PRINT "ENTER ACTIVITY NUMBERS THAT ARE LI
KELY TO BE AFFECTED BY SPACE CONGESTION"
7810 PRINT "          S.NO      ACTIVITY NO.
   ZONE NUMBER     SPACE REQD."
7820 Q=5:PRINT
7830 FOR X=1 TO SC
7840 LOCATE Q,10:PRINT X:LOCATE Q,20:INPUT ACT
(X):LOCATE Q,42:INPUT ZN(ACT(X)):LOCATE Q,55:I
NPUT SPR(ACT(X))
7850 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 7980
7860 NEXT X:CLS
7870 M$="OP12"
7880 OPEN M$ FOR OUTPUT AS #12
7890 WRITE #12,Z,SC
7900 FOR X=1 TO Z
7910 WRITE #12,SP(X):NEXT X
7920 FOR X=1 TO SC
7930 WRITE #12,ACT(X),ZN(ACT(X)),SPR(ACT(X)):N
EXT X
7940 CLOSE #12:GOTO 8010
7950 IF X=Z THEN CLS:RETURN
7960 PRINT "        ZONE NUMBER
 SPACE AVAILABLE "
7970 RETURN
7980 IF X=SC THEN CLS:RETURN
7990 PRINT "S.NO   ACTIVITY NO.       ZONE NUM
BER        SPACE REQD."
8000 RETURN
8010 CLS:CLEAR
8020 DIM AB(50,4),ABI(50,4),F(100),T(100),B$(
100),C(100),MO$(12),A(200),MO(100),EM(100),F$
(100),ACT(50),MPR(50)
8030 SCREEN 2
8040 M$="OP1":OPEN M$ FOR INPUT AS #2:INPUT #
2,DN,N,NN,ST,EN:FOR X=1 TO N:INPUT #2,F(X),T(
X),B$(X),C(X):NEXT X:CLOSE #2
8050 GOSUB 8780
```

```
8060 CLS
8070 REM CREW ABSENTEEISM AND THEIR IMPACT
8080 PRINT "           MONTH              MIDWEEK
 DAYS        WEEK BEGINNING/END DAYS"
8090 PRINT
8100 PRINT "                              FROM
 TO          FROM          TO"
8110 LINE (10,1)-(10,199):LINE(150,1)-(150,19
9):LINE(250,1)-(250,199)
8120 LINE (325,1)-(325,199):LINE(450,10)-(450
,199):LINE(550,1)-(550,199)
8130 PRINT
8140 LOCATE 5,10:PRINT "JAN":LOCATE 5,25:INPU
T AB(1,1):LOCATE 5,35:INPUT AB(1,2):LOCATE 5,
48:INPUT AB(1,3):LOCATE 5,60:INPUT AB(1,4)
8150 LOCATE 7,10:PRINT "FEB ":LOCATE 7,25:INP
UT AB(2,1):LOCATE 7,35:INPUT AB(2,2):LOCATE 7
,48:INPUT AB(2,3):LOCATE 7,60:INPUT AB(2,4)
8160 LOCATE 9,10:PRINT "MAR ":LOCATE 9,25:INP
UT AB(3,1):LOCATE 9,35:INPUT AB(3,2):LOCATE 9
,48:INPUT AB(3,3):LOCATE 9,60:INPUT AB(3,4)
8170 LOCATE 11,10:PRINT "APR ":LOCATE 11,25:I
NPUT AB(4,1):LOCATE 11,35:INPUT AB(4,2):LOCAT
E 11,48:INPUT AB(4,3):LOCATE 11,60:INPUT AB(4
,4)
8180 LOCATE 13,10:PRINT "MAY ":LOCATE 13,25:I
NPUT AB(5,1):LOCATE 13,35:INPUT AB(5,2):LOCAT
E 13,48:INPUT AB(5,3):LOCATE 13,60:INPUT AB(5
,4)
8190 LOCATE 15,10:PRINT "JUN ":LOCATE 15,25:I
NPUT AB(6,1):LOCATE 15,35:INPUT AB(6,2):LOCAT
E 15,48:INPUT AB(6,3):LOCATE 15,60:INPUT AB(6
,4)
8200 LOCATE 17,10:PRINT "JUL ":LOCATE 17,25:I
NPUT AB(7,1):LOCATE 17,35:INPUT AB(7,2):LOCAT
E 17,48:INPUT AB(7,3):LOCATE 17,60:INPUT AB(7
,4)
8210 LOCATE 19,10:PRINT "AUG ":LOCATE 19,25:I
NPUT AB(8,1):LOCATE 19,35:INPUT AB(8,2):LOCAT
E 19,48:INPUT AB(8,3):LOCATE 19,60:INPUT AB(8
,4)
8220 LOCATE 21,10:PRINT "SEP ":LOCATE 21,25:INPUT
AB(9,1):LOCATE 21,35:INPUT AB(9,2):LOCATE 21,48:INPUT
AB(9,3):LOCATE 21,60:INPUT AB(9,4)
8230 LOCATE 23,10:PRINT "OCT ":LOCATE 23,25:INPUT AB(1
0,1):LOCATE 23,35:INPUT AB(10,2):LOCATE 23,48:INPUT AB
(10,3):LOCATE 23,60:INPUT AB(10,4)
8240 PRINT :PRINT :PRINT:PRINT
8250 LINE (10,150)-(10,199):LINE(150,150)-(150,199):LI
NE(250,150)-(250,199)
8260 LINE (325,150)-(325,199):LINE(450,150)-(450,199):
LINE(550,150)-(550,199)
8270 LOCATE 21,10:PRINT "NOV ":LOCATE 21,25:INPUT AB(1
1,1):LOCATE 21,35:INPUT AB(11,2):LOCATE 21,48:INPUT AB
```

```
(11,3):LOCATE 21,60:INPUT AB(11,4)
8280 LOCATE 23,10:PRINT "DEC ":LOCATE 23,25:INPUT AB(1
2,1):LOCATE 23,35:INPUT AB(12,2):LOCATE 23,48:INPUT AB
(12,3):LOCATE 23,60:INPUT AB(12,4)
8290 CLS
8300 PRINT "HOW MANY TACTICAL PLAN ACTIVITIES ARE AFFE
CTED BY ABSENTEEISM"
8310 INPUT CA
8320 PRINT "ENTER ACTIVITY NUMBERS THAT ARE LIKELY TO BE
AFFECTED BY CREW ABSENTEEISM"
8330 FOR X=1 TO CA
8340 INPUT "ACTIVITY NUMBER ";ACT(X):PRINT
8350 NEXT X
8360 CLS
8370 REM IMPACT  OF ABSENTEEISM
8380 PRINT "ACTIVITY   DESCRIPTION                    IMPACT
 IN TERMS OF WORKDAY LOSS"
8390 PRINT "NO.        DESCRIPTION                  ONE CREW
ABSENT      TWO CREW ABSENT  "
8400 PRINT "                                          FROM
  TO       FROM        TO "
8410 LINE (1,25)-(600,25)
8420 LINE (70,1)-(70,190):LINE(275,1)-(275,190)
8430 LINE(350,20)-(350,190):LINE(435,10)-(435,190):LINE(5
25,20)-(525,190):LINE(600,1)-(600,190)
8440 Q=5:GOTO 8450
8450 FOR X= 1 TO CA
8460 LOCATE Q,5:PRINT ACT(X):LOCATE Q,10:PRINT B$(ACT(X))
:LOCATE Q,37:INPUT ABI(ACT(X),1)
8470 LOCATE Q,45:INPUT ABI(ACT(X),2):LOCATE Q,56:INPUT AB
I(ACT(X),3):LOCATE Q,67:INPUT ABI(ACT(X),4)
8480 Q=Q+2
8490 IF Q = 23 THEN CLS:Q=5:GOSUB 8520
8500 NEXT X:CLS
8510 GOTO 8600
8520 IF X = CA THEN RETURN
8530 PRINT "ACTIVITY   ACTIVITY                       IMPACT
 IN TERMS OF WORKDAY LOSS"
8540 PRINT "NO.        DESCRIPTION                  ONE CREW
 ABSENT      TWO CREW ABSENT  "
8550 PRINT "                                          FROM
   TO        FROM       TO"
8560 LINE (1,25)-(600,25)
8570 LINE (70,1)-(70,190):LINE(275,1)-(275,190)
8580 LINE(350,20)-(350,190):LINE(435,10)-(435,190):LINE(5
25,20)-(525,190):LINE(600,1)-(600,190)
8590 RETURN
8600 MO$(6)="JUNE":MO$(7)="JULY":MO$(8)="AUGUST":MO$(9)="
SEPT":MO$(10)="OCT":MO$(11)="NOV":MO$(12)="DEC"
8610 PRINT "INDICATE MANPOWER POSITION FOR THE TACTICAL P
LAN PERIOD"
8620 YE=MO(1)
8630 FOR MP=YE TO YE+4
8640 PRINT "MANPOWER REQUIREMENT FOR THE MONTH OF  "; MO$
```

```
(MP):INPUT EM(MP)
8650 NEXT MP
8660 H$="OP11"
8670 OPEN H$ FOR OUTPUT AS #11
8680 FOR X=1 TO 12:FOR Y=1 TO 4
8690 WRITE #11,AB(X,Y):NEXT Y:NEXT X
8700 WRITE #11,CA,DN,N,YE
8710 FOR X=YE TO YE+4:WRITE #11,EM(X):NEXT X
8720 FOR X=1 TO DN:WRITE #11,MO(X):NEXT X
8730 FOR X=1 TO CA
8740 WRITE #11,ACT(X),ABI(ACT(X),1),ABI(ACT(X),2),ABI(ACT
(X),3),ABI(ACT(X),4)
8750 NEXT X
8760 CLOSE #11
8770 GOTO 8990
8780 LINE INPUT "PROJECT";LA$
8790 CALFL$="A:"+LA$+".CFL"
8800 OPEN CALFL$ AS 1 LEN=4
8810 FOR X = 1 TO DN
8820 C = X+ST-1
8830 GOSUB 8850:NEXT X:CLOSE #1
8840 RETURN
8850 Z = 1
8860 FIELD Z,2 AS MD$, 2 AS YR$
8870 GET Z,C
8880 DT$=STR$(CVI(MD$))
8890 M = INT (CVI(MD$)/100)
8900 D$=RIGHT$(DT$,2)
8910 YR=CVI(YR$)
8920 P$ = D$
8930 Q$ =STR$(YR)
8940 K$= RIGHT$(Q$,2)
8950 J$ = STR$(M):MO(X)=VAL(J$)
8960 DTE$ = P$+"/"+J$+"/"+K$
8970 F$(X)=DTE$
8980 RETURN
8990 DIM ACTR(100),RE(50,4)
9000 PRINT "INDICATE TOTAL NUMBER OF ACTIVITIES THAT ARE
LIKELY TO HAVE THE IMPACT OF REG.REQUIREMENT"
9010 INPUT RER
9020 PRINT "1.ENTER ACTIVITY NUMBERS THAT ARE LIKELY TO H
AVE THE IMPACT OF REG.REQIREMENT"
9030 PRINT "2.INDICATE THE RANGE OF EXPECTED WORKDAY LOSS
 ON EACH DAY ON SUCH ACTIVITIES"
9040 PRINT "3.ALSO INDICATE RANGE OF TOTAL WORKDAY LOSS E
XPECTED AT THE END OF SUCH ACTIVITIES"
9050 FOR X=1 TO 4000:J=0:NEXT X:CLS
9060 PRINT "S.NO       ACT NO.                      EXPECTED
WORKDAY LOSS"
9070 PRINT "                                        DAILY BASIS
       AT END OF ACTY"
9080 PRINT "                                        FROM     TO
      FROM  TO "
9090 Q=5
```

```
9100 FOR X=1 TO RER
9110 LOCATE Q,1:PRINT X:LOCATE Q,10:INPUT ACTR(X):LOCAT
E Q,30:INPUT RE(ACTR(X),1):LOCATE Q,40:INPUT RE(ACTR(X)
,2):LOCATE Q,55:INPUT RE(ACTR(X),3):LOCATE Q,65:INPUT R
E(ACTR(X),4)
9120 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 9210
9130 NEXT X:CLS
9140 M$="OP13"
9150 OPEN M$ FOR OUTPUT AS #13
9160 WRITE #13,RER
9170 FOR X=1 TO RER
9180 WRITE #13,ACTR(X),RE(ACTR(X),1),RE(ACTR(X),2),RE(A
CTR(X),3),RE(ACTR(X),4)
9190 NEXT X
9200 CLOSE #13:GOTO 9260
9210 IF X=RER THEN CLS:RETURN
9220 PRINT "S.NO       ACT NO.                      EXPETED W
ORKDAY LOSS"
9230 PRINT "                                        DAILY BASIS
      AT END OF ACTY"
9240 PRINT "                                         FROM    TO
        FROM  TO "
9250 RETURN
9260 DIM DC(50,4),ACTU(50):CLS
9270 PRINT "INDICATE TOTAL NUMBER OF ACTIVITIES THAT AR
E LIKELY TO HAVE THE IMPACT OF DES.CHANGES AND REWORK"
9280 INPUT DC
9290 PRINT "1.ENTER ACTIVITY NUMBERS THAT ARE LIKELY TO
 HAVE THE IMPACT OF DES.CHANGES AND REWORK"
9300 PRINT "2.INDICATE THE RANGE OF EXPECTED WORKDAY LO
SS ON EACH DAY ON SUCH ACTIVITIES"
9310 PRINT "3.ALSO INDICATE RANGE OF TOTAL WORKDAY LOSS
 EXPECTED AT THE END OF SUCH ACTIVITIES"
9320 FOR X=1 TO 4000:J=0:NEXT X:CLS
9330 PRINT "S.NO       ACT NO.                      EXPECTED
WORKDAY LOSS"
9340 PRINT "                                        DAILY BASIS
      AT END OF ACTY"
9350 PRINT "                                         FROM    TO
        FROM  TO "
9360 Q=5
9370 FOR X=1 TO DC
9380 LOCATE Q,1:PRINT X:LOCATE Q,10:INPUT ACTU(X):LOCAT
E Q,30:INPUT DC(ACTU(X),1):LOCATE Q,35:INPUT DC(ACTU(X)
,2):LOCATE Q,45:INPUT DC(ACTU(X),3):LOCATE Q,55:INPUT D
C(ACTU(X),4)
9390 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 9480
9400 NEXT X:CLS
9410 M$="OP13"
9420 OPEN M$ FOR APPEND AS #13
9430 WRITE #13,DC
9440 FOR X=1 TO DC
9450 WRITE #13,ACTU(X),DC(ACTU(X),1),DC(ACTU(X),2),DC(A
CTU(X),3),DC(ACTU(X),4)
```

```
9460 NEXT X
9470 CLOSE #13:GOTO 9530
9480 IF X=DC THEN CLS:RETURN
9490 PRINT "S.NO      ACT NO.                    EXPECTED
WORKDAY LOSS"
9500 PRINT "                                     DAILY BASIS
     AT END OF ACTY"
9510 PRINT "                                     FROM    TO
     FROM  TO "
9520 RETURN
9530 REM IMPACT DUE TO LABOR UNREST
9540 DIM LU(50),ACTL(50),PROD(50)
9550 INPUT "HOW MANY TOTAL DAYS OF LABOR UNREST IS EXPE
CTED ?";LU
9560 FOR X=1 TO LU
9570 PRINT "INDICATE PROJECT WORKDAY NUMBER OF EXPECTED
 LABOR UNREST DAY";X;
9580 INPUT LU(X):LU(X)=LU(X)-ST+1
9590 NEXT X
9600 REM PRODUCTIVITY LOSS EXPECTED DURING LABOR UNREST
 DAY
9610 PRINT "INDICATE TOTAL NUMBER OF ACTIVITIES THAT AR
E LIKELY TO BE AFFECTED BY LABOR UNREST"
9620 INPUT ALU
9630 PRINT "INDICATE ACTIVITY NUMBERS AND EXPECTED PROD
UCTIVITY LOSS"
9640 CLS
9650 PRINT "S.NO          ACT NO.                EXPECTED P
ROD.LOSS"
9660 Q=5
9670 FOR X=1 TO ALU
9680 LOCATE Q,10:PRINT X:LOCATE Q,25:INPUT ACTL(X):LOCA
TE Q,40:INPUT PROD(ACTL(X))
9690 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 9950
9700 NEXT X:CLS
9710 M$="OP14"
9720 OPEN M$ FOR OUTPUT AS #14
9730 WRITE #14,LU,ALU
9740 FOR X=1 TO LU:WRITE #14,LU(X):NEXT X
9750 FOR X=1 TO ALU:WRITE #14,ACTL(X),PROD(ACTL(X)):NEX
T X
9760 CLOSE #14
9770 DIM SPE(40,2),SPE$(40),SPEC(40):PRINT "INDICATE HO
W MANY ACTIVITIES ARE LIKELY TO HAVE SPECIFIC SIGNIFICA
NT UNCERTAINTIES IN ADDITION TO THOSE LISTED EARLIER"
9780 INPUT SPE
9790 PRINT "INDICATE ACTIVITY NUMBERS ONE BY ONE"
9800 FOR X=1 TO SPE:PRINT "ACTIVITY NUMBER":INPUT;SPEC(
X)
9810 NEXT X
9820 PRINT "GIVE RANGE OF EXPECTED DELAY AND DESCRIPTIO
N OF EACH UNCERTAINTY"
9830 FOR X=1 TO SPE
9840 PRINT "DESCRIPTION OF UNCERTAINTY VARIABLE FOR ACT
```

```
Y";SPEC(X)
9850 LINE INPUT ;SPE$(SPEC(X))
9860 PRINT "GIVE RANGE OF EXPECTED DELAY (FROM,TO)"
9870 INPUT SPE(SPEC(X),1),SPE(SPEC(X),2)
9880 NEXT X
9890 M$="OP6"
9900 OPEN M$ FOR OUTPUT AS #4
9910 WRITE #4,SPE
9920 FOR X=1 TO SPE:WRITE #4,SPEC(X),SPE$(SPEC(X)),SPE(
SPEC(X),1),SPE(SPEC(X),2)
9930 NEXT X:CLOSE #4
9940 PRINT "LOAD FILE ITE.BAS":END
9950 IF X=ALU THEN CLS:RETURN
9960 PRINT "      S.NO    ACT NO.       EXPECTED PROD LO
SS"
9970 RETURN
9980 PRINT "IS THERE ANY ADDITIONAL ACTIVITIES CONSIDER
ED (YES/NO)?"
9990 LINE INPUT ADD$
10000 IF ADD$="YES" THEN 10020
10010 GOTO 13190
10020 PRINT "IS THERE ANY IMPACT OF L.C. ON THE DURATIO
N OF NEW ACTIVITIES (YES/NO) ?"
10030 LINE INPUT ;AR$
10040 IF AR$="YES" THEN 10050 ELSE 10320
10050 DIM ACT(50),V(100),U(100),TS(100),DV(100):M$="OP2
"
10060 OPEN M$ FOR INPUT AS #3
10070 INPUT #3,LC:FOR X=1 TO LC:INPUT #3,ACT(X):NEXT X
10080 FOR X=1 TO N-NN
10090 INPUT #3,V(X),U(X),TS(X),DV(X)
10100 NEXT X
10110 CLOSE #3
10120 PRINT "HOW MANY OUT OF NEW ACTIVITIES ARE LIKELY
TO HAVE IMPACT OF L.C.?"
10130 INPUT ;LCC
10140 PRINT "INDICATE ONE BY ONE ACTIVITY NO.WHICH ARE
LIKELY TO HAVE L.C.IMPACT "
10150 FOR X= LC+1 TO LC+LCC
10160 INPUT "ACTIVITY NO";ACT(X)
10170 NEXT X
10180 PRINT "INDICATE SEQUENTIALLY (SEPARATED BY COMMAS
) THE FOLLOWING DETAILS:VOL OF WORK,UNIT QUANTITY,TIME
FOR FIRST UNIT,EXPECTED VARIATION IN D.C"
10190 FOR X=LC+1 TO LC+LCC
10200 INPUT "ACTIVITY NO;ACT(X)";V(ACT(X)),U(ACT(X)),TS
(ACT(X)),DV(ACT(X))
10210 NEXT X
10220 LC=LC+LCC
10230 M$="OP2"
10240 OPEN M$ FOR OUTPUT AS #3
10250 WRITE #3,LC
10260 FOR X=1 TO LC
10270 WRITE #3,ACT(X):NEXT X
```

```
10280 FOR X=1 TO N
10290 WRITE #3,V(X),U(X),TS(X),DV(X)
10300 NEXT X
10310 CLOSE #3
10320 CLEAR:DIM T1(100),T2(100),T3(100),T4(100),F(100),
T(100),C(100),ACT(100)
10330 PRINT "IS THERE ANY IMPACT OF WEATHER ON THE DURA
TION OF NEW ACTIVITIES (YES/NO) ?"
10340 LINE INPUT ;AR$
10350 IF AR$="YES" THEN 10360 ELSE 10730
10360 H$="OP5"
10370 OPEN H$ FOR INPUT AS #7
10380 INPUT #7,WI:FOR X=1 TO WI:INPUT #7,ACT(X):NEXT X
10390 FOR X= 1 TO WI:INPUT #7,T1(ACT(X)),T2(ACT(X)),T3(
ACT(X)),T4(ACT(X)),F(ACT(X)),T(ACT(X)),C(ACT(X))
10400 NEXT X
10410 CLOSE #7
10420 PRINT "HOW MANY OUT OF NEW ACTIVITIES ARE AFFECTE
D BY WEATHER CONDITIONS"
10430 INPUT ;WII
10440 PRINT "ENTER ACTIVITY NUMBERS THAT ARE LIKELY TO
BE AFFECTED BY WEATHER CONDITIONS"
10450 FOR X=WI+1 TO WI+WII
10460 INPUT "ACTIVITY NUMBER";ACT(X)
10470 NEXT X
10480 X=WI+1
10490 REM TO CALCULATE THE IMPACT OF THE WEATHER
10500 PRINT "ACTY  ACTY                    T E M P IN DEG.
C             SNOW  RAI  "
10510 PRINT "NO.   DESCRIPTION
              >10   >5 "
10520 PRINT "                              <0   <10    <15
  >20         C M   M M  "
10530 LINE (45,1)-(45,199):LINE (175,1)-(175,199)
10540 LINE (195,1)-(195,199):LINE(240,10)-(240,199):LIN
E (290,10)-(290,199):LINE (340,10)-(340,199)
10550 LINE(390,1)-(390,199):LINE(435,1)-(435,199):LINE(
482,1)-(482,199):LINE (540,1)-(540,199):LINE (590,1)-(5
90,199)
10560 FOR L=36 TO 199 STEP 16
10570 LINE (1,L)-(590,L)
10580 NEXT L
10590 FOR Q=6 TO 24 STEP 2
10600 LOCATE Q,2:PRINT X:LOCATE Q,7:PRINT B$(X)
10610 LOCATE Q,26:INPUT ;T1(ACT(X)):LOCATE Q,32:INPUT ;
T2(ACT(X)):LOCATE Q,38:INPUT ;T3(ACT(X)):LOCATE Q,44:IN
PUT;T4(ACT(X)):LOCATE Q,50:LOCATE Q,56:INPUT T(ACT(X)):
LOCATE Q,63:INPUT ;C(ACT(X))
10620 X=X+1:IF X >WI+WII THEN  10660
10630 NEXT Q
10640 CLS:GOTO 10490
10650 CLS
10660 WI=WI+WII
10670 H$="OP5"
```

```
10680 OPEN H$ FOR OUTPUT AS #7
10690 WRITE #7,WI:FOR X=1 TO WI:WRITE #7,ACT(X):NEXT X
10700 FOR X= 1 TO WI:WRITE #7,T1(ACT(X)),T2(ACT(X)),T3(
ACT(X)),T4(ACT(X)),F(ACT(X)),T(ACT(X)),C(ACT(X))
10710 NEXT X
10720 CLOSE #7
10730 PRINT "IS THERE ANY IMPACT OF SPACE CONGESTION ON
 THE DURATION OF NEW ACTIVITIES (YES/NO) ?"
10740 LINE INPUT ;AR$
10750 IF AR$="YES" THEN 10760 ELSE 11180
10760 XLEAR:DIM SP(25),ACTS(25),ZN(100),SPR(100),SSP(10
0):M$="OP12"
10770 OPEN M$ FOR INPUT AS #12
10780 INPUT #12,Z,SC
10790 FOR X=1 TO Z
10800 INPUT #12,SP(X):NEXT X
10810 FOR X=1 TO SC
10820 INPUT #12,ACTS(X),ZN(ACTS(X)),SPR(ACTS(X)):NEXT X
10830 CLOSE #12
10840 PRINT "INDICATE ANY ADDITIONAL ZONES EXPECTED TO
HAVE SPACE CONSTRAINT"
10850 INPUT ZO
10860 PRINT "          ZONE NUMBER                  SPACE A
VAILABLE "
10870 Q=5:PRINT
10880 FOR X=Z+1 TO Z+ZO
10890 LOCATE Q,20:PRINT X:LOCATE Q,40:INPUT ;SP(X)
10900 SSP(X)=SP(X)
10910 Q=Q+2:IF Q=23 THEN CLS:GOSUB 11120
10920 NEXT X
10930 Z=Z+ZO
10940 PRINT "INDICATE TOTAL OUT OF ADDITIONAL ACTIVITIE
S WHICH ARE LIKELY TO HAVE SPACE CONSTRAINT"
10950 INPUT ;SCC
10960 PRINT "ENTER ACTIVITY NUMBERS THAT ARE LIKELY TO
BE AFFECTED BY SPACE CONGESTION"
10970 PRINT "       S.NO      ACTIVITY NO.           ZONE
 NUMBER     SPACE REQD."
10980 Q=5:PRINT
10990 FOR X=SC+1 TO SC+SCC
11000 LOCATE Q,10:PRINT X:LOCATE Q,20:INPUT ACT(X):LOCA
TE Q,42:INPUT ZN(ACT(X)):LOCATE Q,55:INPUT SPR(ACT(X))
11010 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 11150
11020 NEXT X:CLS
11030 SC=SC+SCC
11040 M$="OP12"
11050 OPEN M$ FOR OUTPUT AS #12
11060 WRITE #12,Z,SC
11070 FOR X=1 TO Z
11080 WRITE #12,SP(X):NEXT X
11090 FOR X=1 TO SC
11100 WRITE #12,ACT(X),ZN(ACT(X)),SPR(ACT(X)):NEXT X
11110 CLOSE #12:GOTO 11180
11120 IF X=Z+ZO THEN CLS:RETURN
```

```
11130 PRINT "        ZONE NUMBER,                  SPACE A
VAILABLE "
11140 RETURN
11150 IF X=SC THEN CLS:RETURN
11160 PRINT "S.NO   ACTIVITY NO.      ZONE NUMBER
  SPACE REQD."
11170 RETURN
11180 PRINT "IS THERE ANY IMPACT OF ABSENTEEISM ON THE
DURATION OF NEW ACTIVITIES (YES/NO) ?"
11190 LINE INPUT ;AR$
11200 IF AR$="YES" THEN 11210 ELSE 11910
11210 CLEAR:SCREEN 2:DIM AB(12,4),EM(12),MO(100),ACT(10
0),ABI(100,4),MPR(100),F(50),T(50),B$(50),C(50),F$(100)
,MO$(12)
11220 H$="OP11"
11230 OPEN H$ FOR INPUT  AS #11
11240 FOR X=1 TO 12:FOR Y=1  TO 4
11250 INPUT #11,AB(X,Y):NEXT Y:NEXT X
11260 INPUT #11,CA,DN,N,YE
11270 FOR X=YE TO YE+4:INPUT #11,EM(X):NEXT X
11280 FOR X=1 TO DN:INPUT #11,MO(X):NEXT  X
11290 FOR X=1 TO CA
11300 INPUT #11,ACT(X),ABI(ACT(X),1),ABI(ACT(X),2),ABI(
ACT(X),3),ABI(ACT(X),4)
11310 NEXT X
11320 CLOSE #11
11330 M$="OP1":OPEN M$ FOR INPUT AS #2
11340 INPUT #2,DN,N,NN,ST,EN:FOR X=1 TO N:INPUT #2,F(X)
,T(X),B$(X),C(X):NEXT  X:CLOSE #2
11350 GOSUB 8780
11360 PRINT "INDICATE TOTAL  OUT OF NEW ACTIVITIES THAT
ARE LIKELY TO BE AFFECTEDBY ABSENTEEISM"
11370 INPUT ;CAA
11380 PRINT "ENTER ACTIVITY NUMBERS THAT ARE LIKELY  TO
BE AFFECTED BY CREW ABSENTEEISM"
11390 FOR X=CA+1 TO CA+CAA
11400 INPUT "ACTIVITY NUMBER ";ACT(X):PRINT
11410 NEXT X
11420 CLS
11430 REM IMPACT  OF ABSENTEEISM
11440 PRINT "ACTIVITY   DESCRIPTION                 IMP
ACT IN TERMS OF WORKDAY LOSS"
11450 PRINT "NO.        DESCRIPTION                 ONE CR
EW ABSENT      TWO CREW ABSENT   "
11460 PRINT "                                          FROM
     TO        FROM          TO "
11470 LINE (1,25)-(600,25)
11480 LINE (70,1)-(70,190):LINE(275,1)-(275,190)
11490 LINE(350,20)-(350,190):LINE(435,10)-(435,190):LIN
E(525,20)-(525,190):LINE(600,1)-(600,190)
11500 Q=5
11510 FOR X=CA+1 TO CA+CAA
11520 LOCATE Q,5:PRINT ACT(X):LOCATE Q,10:PRINT B$(ACT(
X)):LOCATE Q,37:INPUT ABI(ACT(X),1)
```

```
11530 LOCATE Q,45:INPUT ABI(ACT(X),2):LOCATE Q,56:INPUT
 ABI(ACT(X),3):LOCATE Q,67:INPUT ABI(ACT(X),4)
11540 Q=Q+2
11550 IF Q=23 THEN CLS:Q=5:GOSUB 11580
11560 NEXT X:CLS
11570 GOTO 11660
11580 IF X=CA+CAA THEN RETURN
11590 PRINT "ACTIVITY   ACTIVITY                    IMP
ACT IN TERMS OF WORKDAY LOSS"
11600 PRINT "NO.        DESCRIPTION                 ONE C
REW ABSENT        TWO CREW ABSENT  "
11610 PRINT "                                       FROM
      TO          FROM         TO"
11620 LINE (1,25)-(600,25)
11630 LINE (70,1)-(70,190):LINE(275,1)-(275,190)
11640 LINE(350,20)-(350,190):LINE(435,10)-(435,190):LIN
E(525,20)-(525,190):LINE(600,1)-(600,190)
11650 RETURN
11660 MO$(6)="JUNE":MO$(7)="JULY":MO$(8)="AUGUST":MO$(9
)="SEPT":MO$(10)="OCT":MO$(11)="NOV":MO$(12)="DEC"
11670 MO$(1)="JAN":MO$(2)="FEB":MO$(3)="MARCH":MO$(4)="
APR":MO$(5)="MAY"
11680 PRINT "INDICATE MANPOWER POSITION FOR THE TACTICA
L PLAN PERIOD"
11690 NMP=MP
11700 YE=MO(1)
11710 FOR MP=YE TO YE + 4:NP=MP
11720 IF MP > 12 THEN NP=MP-12
11730 PRINT "MANPOWER REQUIREMENT FOR THE MONTH OF  ";
MO$(NP):INPUT EM(NP)
11740 NEXT MP
11750 PRINT "INDICATE ACTIVITYWISE MANPOWER REQUIREMENT
"
11760 FOR Y=N-NN TO N
11770 PRINT "MANPOWER REQUIRED FOR ACTIVITY NO";Y;"IS"
11780 INPUT MPR(Y):NEXT Y
11790 CA=CA+CAA
11800 H$="OP11"
11810 OPEN H$ FOR OUTPUT AS #11
11820 FOR X=1 TO 12:FOR Y=1 TO 4
11830 WRITE #11,AB(X,Y):NEXT Y:NEXT X
11840 WRITE #11,CA,DN,N,YE
11850 FOR X=YE TO YE+4:WRITE #11,EM(X):NEXT X
11860 FOR X=1 TO DN:WRITE #11,MO(X):NEXT X
11870 FOR X=1 TO CA
11880 WRITE #11,ACT(X),ABI(ACT(X),1),ABI(ACT(X),2),ABI(
ACT(X),3),ABI(ACT(X),4)
11890 NEXT X
11900 CLOSE #11
11910 PRINT "IS THERE ANY IMPACT OF R.R ON THE DURATION
 OF NEW ACTIVITIES (YES/NO) ?"
11920 LINE INPUT ;AR$
11930 IF AR$="YES" THEN 11940 ELSE 12230
11940 CLEAR:DIM ACTR(100),DC(100,4),RE(100,4),ACTU(100)
```

```
:M$="OP13"
11950 OPEN M$ FOR INPUT AS #13
11960 INPUT #13,RER
11970 FOR X=1 TO RER
11980 INPUT #13,ACTR(X),RE(ACTR(X),1),RE(ACTR(X),2),RE(
ACTR(X),3),RE(ACTR(X),4)
11990 NEXT X
12000 INPUT #13,DC
12010 FOR X=1 TO DC
12020 INPUT #13,ACTU(X),DC(ACTU(X),1),DC(ACTU(X),2),DC(
ACTU(X),3),DC(ACTU(X),4)
12030 NEXT X
12040 CLOSE #13
12050 PRINT "INDICATE TOTAL OUT OF NEW ACTIVITIES THAT
ARE EXPECTED TO HAVE THE IMPACT OF REG.REQUIREMENT"
12060 INPUT RERR
12070 CLS
12080 PRINT "S.NO      ACT NO.                  EXPECTED
 WORKDAY LOSS"
12090 PRINT "                                 DAILY BASIS
       AT END OF ACTY"
12100 PRINT "                                  FROM    TO
         FROM  TO "
12110 Q=5
12120 FOR X=RER+1 TO RER+RERR
12130 LOCATE Q,1:PRINT X:LOCATE Q,10:INPUT ACTR(X):LOCA
TE Q,30:INPUT RE(ACTR(X),1):LOCATE Q,40:INPUT RE(ACTR(X
),2):LOCATE Q,55:INPUT RE(ACTR(X),3):LOCATE Q,65:INPUT
RE(ACTR(X),4)
12140 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 12180
12150 NEXT X:CLS
12160 RER=RER+RERR
12170 GOTO 12230
12180 IF X=RER+RERR THEN CLS:RETURN
12190 PRINT "S.NO      ACT NO.                  EXPECTED
 WORKDAY LOSS"
12200 PRINT "                                 DAILY BASIS
       AT END OF ACTY"
12210 PRINT "                                  FROM    TO
         FROM  TO "
12220 RETURN
12230 PRINT "IS THERE ANY IMPACT OF DES.CHANGE ON THE D
URATION OF NEW ACTIVITIES (YES/NO) ?"
12240 LINE INPUT ;AR$
12250 IF AR$="YES" THEN 12260 ELSE 12380
12260 PRINT "INDICATE TOTAL OUT OF NEW ACTIVITIES THAT
ARE LIKELY TO HAVE IMPACT OF DESIGN CHANGES"
12270 INPUT ;DCC
12280 CLS
12290 PRINT "S.NO      ACT NO.                  EXPECTED
 WORKDAY LOSS"
12300 PRINT "                                 DAILY BASIS
       ATEND OF ACTY"
12310 PRINT "                                  FROM    TO
```

```
    FROM  TO "
12320 Q=5
12330 FOR X=DC+1 TO DC+DCC
12340 LOCATE Q,1:PRINT X:LOCATE Q,10:INPUT ACTU(X):LOCA
TE Q,30:INPUT DC(ACTU(X),1):LOCATE Q,40:INPUT DC(ACTU(X
),2):LOCATE Q,55:INPUT DC(ACTU(X),3):LOCATE Q,65:INPUT
DC(ACTU(X),4)
12350 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 12490
12360 NEXT X:CLS
12370 DC=DC+DCC
12380 M$="OP13"
12390 OPEN M$ FOR OUTPUT AS #13
12400 WRITE #13,RER
12410 FOR X=1 TO RER
12420 WRITE #13,ACTR(X),RE(ACTR(X),1),RE(ACTR(X),2),RE(
ACTR(X),3),RE(ACTR(X),4)
12430 NEXT X
12440 WRITE #13,DC
12450 FOR X=1 TO DC
12460 WRITE #13,ACTU(X),DC(ACTU(X),1),DC(ACTU(X),2),DC(
ACTU(X),3),DC(ACTU(X),4)
12470 NEXT X
12480 CLOSE #13:GOTO 12540
12490 IF X=DC+DCC THEN CLS:RETURN
12500 PRINT "S.NO     ACT NO.                    EXPECTED
 WORKDAY LOSS"
12510 PRINT "                                   DAILY BASIS
     ATEND OF ACTY"
12520 PRINT "                                   FROM    TO
     FROM  TO "
12530 RETURN
12540 CLEAR:DIM F(100),T(100),B$(100),C(100),LU(100),AC
TL(100),PROD(100)
12550 M$="OP1":OPEN M$ FOR INPUT AS #2
12560 INPUT #2,DN,N,NN,ST,EN:FOR X=1 TO N:INPUT #2,F(X)
,T(X),B$(X),C(X):NEXT X:CLOSE #2
12570 M$="OP14"
12580 OPEN M$ FOR INPUT  AS #14
12590 INPUT #14,LU,ALU
12600 FOR X=1 TO LU:INPUT #14,LU(X):LU(X)=0:NEXT X:LU=0
12610 FOR X=1 TO ALU:INPUT #14,ACTL(X),PROD(ACTL(X)):NE
XT X
12620 CLOSE #14
12630 PRINT "IS THERE ANY IMPACT OF LABOR UNREST ON THE
 DURATION OF NEW ACTIVITIES (YES/NO) ?"
12640 LINE INPUT ;AR$
12650 IF AR$="YES" THEN 12660 ELSE 12910
12660 INPUT "HOW MANY TOTAL DAYS OF LABOR UNREST IS EXP
ECTED ?";LU
12670 FOR X=1 TO LU
12680 PRINT "INDICATE PROJECT WORKDAY NUMBER OF EXPECTE
D LABOR UNREST DAY";X;
12690 INPUT LU(X):LU(X)=LU(X)-ST+1
12700 NEXT X
```

```
12710 PRINT "INDICATE TOTAL OUT OF NEW ACTIVITIES THAT
HAVE IMPACT OF LABOR UNREST"
12720 INPUT ALUU
12730 PRINT "INDICATE ACTIVITY NUMBERS AND EXPECTED PRO
DUCTIVITY LOSS"
12740 CLS
12750 PRINT "S.NO         ACT NO.              EXPECTED
PROD.LOSS"
12760 Q=5
12770 FOR X=ALU+1 TO ALU+ALUU
12780 LOCATE Q,10:PRINT X:LOCATE Q,25:INPUT ACTL(X):LOC
ATE Q,40:INPUT PROD(ACTL(X))
12790 Q=Q+2:IF Q=23 THEN CLS:Q=5:GOSUB 12880
12800 NEXT X:CLS
12810 ALU=ALU+ALUU
12820 M$="OP14"
12830 OPEN M$ FOR OUTPUT AS #14
12840 WRITE #14,LU,ALU
12850 FOR X=1 TO LU:WRITE #14,LU(X):NEXT X
12860 FOR X=1 TO ALU:WRITE #14,ACTL(X),PROD(ACTL(X)):NE
XT X
12870 CLOSE #14:GOTO  12910
12880 IF X=ALU+ALUU THEN CLS:RETURN
12890 PRINT "       S.NO     ACT NO.       EXPECTED PROD L
OSS"
12900 RETURN
12910 PRINT "IS THERE ANY IMPACT OF SPECIFIC UNCERTAINT
IES FOR NEW ACTIVITIES (YES/NO)?"
12920 LINE INPUT SPU$
12930 IF SPU$="YES" THEN 12940 ELSE 13180
12940 DIM SPE$(50),SPL(100,2)
12950 M$="OP6"
12960 OPEN M$ FOR INPUT AS #4
12970 INPUT #4,SPE
12980 FOR X=1 TO SPE:INPUT #4,SPE$(SPEC(X)),SPE(SPEC(X)
,1),SPE(SPEC(X),2)
12990 NEXT X:CLOSE #4
13000 PRINT "INDICATE TOTAL OUT OF NEW ACTICITIES THAT
ARE LIKELY TO BE AFFECTEDBY SPECIFIC UNCERTAINTIES"
13010 INPUT ;SPEE
13020 FOR X=SPE+1 TO SPE+SPEE
13030 INPUT "ACTIVITY NUMBER";SPEC(X)
13040 NEXT X
13050 PRINT "GIVE RANGE OF EXPECTED DELAY AND DESCRIPTI
ON OF EACH UNCERTAINTY"
13060 FOR X=SPE+1 TO SPE+SPEE
13070 PRINT "DESCRIPTION OF UNCERTAINTY VARIABLE FOR AC
TY";SPEC(X)
13080 LINE INPUT ;SPE$(SPEC(X))
13090 PRINT "GIVE RANGE OF EXPECTED DELAY (FROM,TO)"
13100 INPUT SPE(SPEC(X),1),SPE(SPEC(X),2)
13110 NEXT X
13120 SPE=SPE+SPEE
13130 M$="OP6"
```

```
13140 OPEN M$ FOR OUTPUT AS #4
13150 WRITE #4,SPE
13160 FOR X=1 TO SPE:WRITE #4,SPEC(X),SPE$(SPEC(X)),SPE
(SPEC(X),1),SPE(SPEC(X),2)
13170 NEXT X:CLOSE #4
13180 PRINT "LOAD FILE WEA.BAS":END
13190 CLEAR:SCREEN 2:DIM AB(12,4),EM(12),MO(100),ACT(10
0),ABI(100,4),MPR(100),F(50),T(50),B$(50),C(50),F$(100)
,MO$(12)
13200 H$="OP11"
13210 OPEN H$ FOR INPUT  AS #11
13220 FOR X=1 TO 12:FOR Y=1 TO 4
13230 INPUT #11,AB(X,Y):NEXT Y:NEXT X
13240 INPUT #11,CA,DN,N,YE
13250 FOR X=YE TO YE+4:INPUT #11,EM(X):NEXT X
13260 FOR X=1 TO DN:INPUT #11,MO(X):NEXT X
13270 FOR X=1 TO CA
13280 INPUT #11,ACT(X),ABI(ACT(X),1),ABI(ACT(X),2),ABI(
ACT(X),3),ABI(ACT(X),4)
13290 NEXT X
13300 CLOSE #11
13310 M$="OP1":OPEN M$ FOR INPUT AS #2
13320 INPUT #2,DN,N,NN,ST,EN:FOR X=1 TO N:INPUT #2,F(X)
,T(X),B$(X),C(X):NEXT X:CLOSE #2
13330 GOSUB 8780
13340 MO$(6)="JUNE":MO$(7)="JULY":MO$(8)="AUGUST":MO$(9
)="SEPT":MO$(10)="OCT":MO$(11)="NOV":MO$(12)="DEC"
13350 PRINT "INDICATE MANPOWER POSITION FOR THE TACTICA
L PLAN PERIOD"
13360 NMP=MP
13370 YE=MO(1)
13380 FOR MP=YE TO YE + 4:NP=MP
13390 IF MP > 12 THEN NP=MP-12
13400 PRINT "MANPOWER REQUIREMENT FOR THE MONTH OF  ";
MO$(NP):INPUT EM(NP)
13410 NEXT MP
13420 H$="OP11"
13430 OPEN H$ FOR OUTPUT AS #11
13440 FOR X=1 TO 12:FOR Y=1 TO 4
13450 WRITE #11,AB(X,Y):NEXT Y:NEXT X
13460 WRITE #11,CA,DN,N,YE
13470 FOR X=YE TO YE+4:WRITE #11,EM(X):NEXT X
13480 FOR X=1 TO DN:WRITE #11,MO(X):NEXT X
13490 FOR X=1 TO CA
13500 WRITE #11,ACT(X),ABI(ACT(X),1),ABI(ACT(X),2),ABI(
ACT(X),3),ABI(ACT(X),4)
13510 NEXT X
13520 CLOSE #11
13530 CLEAR:DIM F(100),T(100),B$(100),C(100),LU(100),AC
TL(100),PROD(100)
13540 M$="OP1":OPEN M$ FOR INPUT AS #2
13550 INPUT #2,DN,N,NN,ST,EN:FOR X=1 TO N:INPUT #2,F(X)
,T(X),B$(X),C(X):NEXT X:CLOSE #2
13560 M$="OP14"
```

```
13570 OPEN M$ FOR INPUT  AS #14
13580 INPUT #14,LU,ALU
13590 FOR X=1 TO LU:INPUT #14,LU(X):LU(X)=0:NEXT X:LU=0
13600 FOR X=1 TO ALU:INPUT #14,ACTL(X),PROD(ACTL(X)):NE
XT X
13610 CLOSE #14
13620 INPUT "HOW MANY TOTAL DAYS OF LABOR UNREST IS EXP
ECTED ?";LU
13630 FOR X=1 TO LU
13640 PRINT "INDICATE PROJECT WORKDAY NUMBER OF EXPECTE
D LABOR UNREST DAY";X;
13650 INPUT LU(X):LU(X)=LU(X)-ST+1
13660 NEXT X
13670 M$="OP14"
13680 OPEN M$ FOR OUTPUT AS #14
13690 WRITE #14,LU,ALU
13700 FOR X=1 TO LU:WRITE #14,LU(X):NEXT X
13710 FOR X=1 TO ALU:WRITE #14,ACTL(X),PROD(ACTL(X)):NE
XT X
13720 CLOSE #14:GOTO  13180
```

```
100 REM *********************************************
110 REM *****                                   *****
120 REM *****      PRODUF COMPUTER MODEL STEP 2 *****
130 REM *****                                   *****
140 REM *********************************************
150 DIM TE(10,12,31),RA(10,12,31),SN(10,7,31),TEM(150),
RAI(150),SNO(100),RN(100)
160 H$="B:WEATHER1"
170 OPEN H$ FOR INPUT AS #3
180 FOR X=1 TO 10
190 FOR Y=1 TO 12
200 FOR Z=1 TO 31
210 INPUT #3,TE(X,Y,Z)
220 NEXT Z
230 NEXT Y
240 FOR Y=1 TO 12
250 FOR Z=1 TO 31
260 INPUT #3,RA(X,Y,Z)
270 NEXT Z
280 NEXT Y
290 NEXT X
300 FOR X=1 TO 10
310 FOR Y=1 TO 4
320 FOR Z=1 TO 31
330 INPUT #3,SN(X,Y,Z)
340 NEXT Z
350 NEXT Y
360 NEXT X
370 FOR X=1 TO 10
380 FOR Y=5 TO 7
390 FOR Z=1 TO 31
400 INPUT #3,SN(X,Y,Z)
410 NEXT Z
420 NEXT Y
430 NEXT X
440 CLOSE #3
450 PRINT "THIS PROGRAM IS TO SIMULATE WEATHER CONDITIO
NS FOR THE TACTICAL PLAN PERIOD"
460 M$="OP1":OPEN M$ FOR INPUT AS #2
470 INPUT #2,DN,N,NN,ST,EN:CLOSE #2
480 PRINT "INDICATE SIMULATION NUMBER "
490 INPUT I
500 RANDOMIZE (I*ST)
510 FOR X=1 TO DN
520 RN(X)=RND(X*I*ST)
530 RN(X)=RN(X)*9
540 RR=INT(1000+.5)
550 N2=INT(RR*RN(X)+.5)
560 RN(X)=N2/RR+1:PRINT X,RN(X)
570 NEXT X
580 LA$="EXAMPLE PROJECT"
590 CALFL$=LA$+".CFL"
600 OPEN CALFL$ AS 1 LEN = 4
610 FOR X=1 TO DN
```

```
620 C=X+ST-1
630 GOSUB 730
640 NEXT X:CLOSE #1
650 H$="OP4"
660 OPEN H$ FOR OUTPUT AS #6:WRITE #6,I
670 FOR X=1 TO DN
680 WRITE #6,TEM(X),RAI(X),SNO(X):PRINT TEM(X),RAI(X),S
NO(X)
690 NEXT X
700 CLOSE #6
710 PRINT "LOAD FILE ITE.BAS"
720 END
730 Z=1
740 FIELD Z,2 AS MD$, 2 AS YR$
750 GET Z,C
760 DT$=STR$(CVI(MD$))
770 M=INT(CVI(MD$)/100)
780 D$=RIGHT$(DT$,2)
790 YR=CVI(YR$)
800 P$=D$
810 Q$=STR$(YR)
820 K$=RIGHT$(Q$,2)
830 J$=STR$(M)
840 D=VAL(P$)
850 TEM(X)=TE(RN(X),M,D)
860 RAI(X)=RA(RN(X),M,D)
870 IF M>4 THEN 880 ELSE 900
880 IF M>9 THEN M=M-5:GOTO 900
890 GOTO 910
900 SNO(X)=SN(RN(X),M,D)
910 RETURN
```

```
100 REM ***********************************************
110 REM *****                                     *****
120 REM *****     PRODUF COMPUTER MODEL STEP 3    *****
130 REM *****                                     *****
140 REM ***********************************************
150 CLEAR
160 REM TO CALCULATE THE RANGE OF ACTIVITY DURATIONS
170 H$="OP4":OPEN H$ FOR INPUT AS #6
180 INPUT #6,I:CLOSE #6
190 M$="OP1"
200 DIM V(50),U(50),TS(50),DV(50),B(50),DC(50),RC(50),RN
(50),DU(50),RB(50),RED(50),NR(50),F(50),T(50),B$(50),C(5
0),A(50),ACT(50)
210 OPEN M$ FOR INPUT AS #2
220 INPUT #2,DN,N,NN,ST,EN
230 FOR X=1 TO N:INPUT #2,F(X),T(X),B$(X),C(X)
240 NEXT X:CLOSE #2:CLS
250 M$="OP2":OPEN M$ FOR INPUT AS #3:INPUT #3,LC:FOR X=1
 TO LC:INPUT #3,ACT(X):NEXT X
260 FOR X = 1 TO N:INPUT #3,V(X),U(X),TS(X),DV(X):NEXT X
270 CLOSE #3
280 FOR X=1 TO N :IF V(X)=0 THEN RED(X)=C(X):GOTO 380
290 IF C(X)=0 THEN 380
300 A(X)=V(X)/U(X):B(X)=C(X)/A(X):DC(X)=LOG(A(X))/LOG(2)
:RC(X)=(B(X)/TS(X))^(1/DC(X))
310 RANDOMIZE(I)
320 RN(X)=RND(I*X):NR(X)=((2*RN(X))-1)
330 RC(X)=RC(X)+(NR(X)*DV(X))
340 DU(X)=(RC(X))^DC(X)
350 RB(X)=DU(X)*TS(X)
360 RED(X)=RB(X)*A(X)
370 RED(X)=INT((INT(10^2+.5))*RED(X)+.5)/INT(10^2+.5)
380 NEXT X
390 M$="OP7"
400 OPEN M$ FOR OUTPUT AS #8:WRITE #8,I
410 FOR X = 1 TO N
420 WRITE #8,RED(X)
430 NEXT X
440 CLOSE #8
450 CLEAR
460 DIM TE(100,10),R(100,10),W(100,10),S(100,10),Z(20),T
(50),F(50),B$(50),C(50),RED(50),TEM(100),RA(100),WI(100)
,SN(100),RN(100)
470 M$="OP1":OPEN M$ FOR INPUT AS #2:WRITE #2,DN,N:CLOSE
 #2
480 M$="OP7"
490 OPEN M$ FOR INPUT  AS #8:INPUT #8,I
500 FOR X = 1 TO N
510 INPUT #8,RED(X)
520 NEXT X :CLOSE #8
530 DIM AB(12,4),MW(12),WE(12),M(200),AS(100),EM(12),MO(
100),MOC(50),MTC(50),ACT(100),ABI(50,4),MPR(50)
540 H$="OP11":OPEN H$ FOR INPUT AS #11
550 FOR X=1 TO 12:FOR Y=1 TO 4:INPUT #11,AB(X,Y)
```

```
560 NEXT Y:NEXT X
570 INPUT #11,CA,DN,N,YE
580 FOR X=YE TO YE+4:INPUT #11,EM(X):NEXT X
590 FOR X=1 TO DN:INPUT #11,MO(X):NEXT X
600 FOR X=1 TO CA:INPUT #11,ACT(X),ABI(ACT(X),1),ABI(ACT
(X),2),ABI(ACT(X),3),ABI(ACT(X),4):NEXT X
610 CLOSE #11
620 FOR X=1 TO 12
630 MW(X)=AB(X,2)-AB(X,1)
640 WE(X)=AB(X,4)-AB(X,3)
650 NEXT X
660 M$="OP1"
670 OPEN M$ FOR INPUT AS #2
680 INPUT #2,DN,N,NN,ST,EN
690 CLOSE #2
700 H$="OP9"
710 OPEN H$ FOR INPUT AS #9
720 INPUT #9,Z:WRITE #9,Z
730 FOR X = 1 TO Z:INPUT #9,M(X):NEXT X
740 CLOSE #9
750 FOR X=1 TO DN:RANDOMIZE(X*I*10):RN(X)=RND(X*I*10)
760 Y=MO(X):AS(X)=(MW(Y)*RN(X)+AB(Y,1))*EM(Y)/100
770 FOR R=1 TO Z
780 IF X=M(R)-ST THEN GOSUB 820:GOTO 800
790 NEXT R
800 NEXT X
810 FOR X=1 TO DN:RR=INT(1000+.5):N2=INT(RR*AS(X)+.5):AS
(X)=N2/RR:NEXT X:GOTO 840
820 AS(X)=(WE(Y)*RN(X)+AB(Y,3))*EM(Y)/100
830 RETURN
840 FOR Y=1 TO CA
850 RANDOMIZE(Y*I*5)
860 RN(Y)=RND(Y*I*5)
870 MOC(ACT(Y))=RN(Y)*(ABI(ACT(Y),2)-ABI(ACT(Y),1))+AB
I(ACT(Y),1)
880 MTC(ACT(Y))=RN(Y)*(ABI(ACT(Y),4)-ABI(ACT(Y),3))+AB
I(ACT(Y),3)
890 NEXT Y
900 H$="OP10"
910 OPEN H$ FOR OUTPUT AS # 10:WRITE #10,YE,CA
920 FOR X=1 TO DN
930 WRITE #10,AS(X)
940 NEXT X
950 FOR Y=1 TO N:WRITE #10,MOC(Y),MTC(Y):NEXT Y
960 FOR Y=YE TO YE+4:WRITE #10,EM(Y):NEXT Y
970 FOR Y=1 TO DN;WRITE #10,MO(Y):NEXT Y
980 CLOSE #10
990 DIM ACTR(50),RE(50,4),ACTU(50),DC(50,4)
,RM(50),RME(50),DM(50),DME(50)
1000 H$="OP13":OPEN H$ FOR INPUT AS #13
1010 INPUT #13,RER
1020 FOR X=1 TO RER:INPUT #13,ACTR(X),R
E(ACTR(X),1),RE(ACTR(X),2),RE(ACTR(X),3
),RE(ACTR(X),4):NEXT X
```

```
1030 INPUT #13,DC:FOR X=1 TO DC:INPUT #13,ACTU(X),
DC(ACTU(X),1),DC(ACTU(X),2),DC(ACTU(X),3),DC(ACTU(
X),4):NEXT X:CLOSE #13
1040 FOR X=1 TO RER:RANDOMIZE(X*I*20):RN(X)=RND(X*
I*I*20)
1050 RM(ACTR(X))=(RE(ACTR(X),2)-RE(ACTR(X),1))*RN(
X)+(RE(ACTR(X),1))
1060 RME(ACTR(X))=(RE(ACTR(X),4)-RE(ACTR(X),3))*RN
(X)+(RE(ACTR(X),3))
1070 NEXT X
1080 FOR X=1 TO DC
1090 RANDOMIZE (X*I*30)
1100 RN(X)=RND(X*I*I*30)
1110 DM(ACTU(X))=(DC(ACTU(X),2)-DC(ACTU(X),1))*RN(
X)+(DC(ACTU(X),1))
1120 DME(ACTU(X))=(DC(ACTU(X),4)-DC(ACTU(X),3))*RN
(X)+(DC(ACTU(X),3))
1130 NEXT X
1140 DIM SPE(100,2),SPE$(50),SPEC(50),UN(50)
1150 M$="OP6"
1160 OPEN M$ FOR INPUT AS #4
1170 INPUT #4,SPE
1180 FOR X=1 TO SPE
1190 INPUT #4,SPEC(X),SPE$(SPEC(X)),SPE(SPEC(X),1)
,SPE(SPEC(X),2)
1200 NEXT X
1210 CLOSE #4
1220 RANDOMIZE(I*I*40)
1230 FOR X=1 TO SPE
1240 RN(X)=RND(X*I*I*I)
1250 UN(SPEC(X))=RN(X)*(SPE(SPEC(X),2)-SPE(SPEC(X)
,1))+SPE(SPEC(X),1)
1260 NEXT X
1270 H$="OP7":OPEN H$ FOR APPEND AS #8
1280 WRITE #8,RER:FOR X=1 TO RER:WRITE #8,ACTR(X):
NEXT X:FOR X=1 TO RER:WRITE #8,RM(ACTR(X)),RME(ACT
R(X)):NEXT X
1290 WRITE #8,DC:FOR X=1 TO DC:WRITE #8,ACTU(X):NE
XT X:FOR X=1 TO DC:WRITE #8,DM(ACTU(X)),DME(ACTU(X
)):NEXT X
1300 WRITE #8,SPE
1310 FOR X=1 TO SPE
1320 WRITE #8,SPEC(X),UN(SPEC(X))
1330 NEXT X
1340 CLOSE #8
1350 CLEAR
1360 DIM T(50),F(50),B$(50),C(50),E(50),L(50),G(50
),J(50),RA(50),RED(50),AW(100),AC(100),CA(50),BW(5
0),F$(100),RR(50),CO(10)
1370 DIM MTC(50),MPR(50),EM(12),SP(20),ACTS(50),ZN
(50),SPR(50),LU(50),ACTL(50),PROD(50),AB(50),WDT(5
0),SC(20),CRI(20),WDS(50),WDR(50),WDD(50)
1380 DIM TEM(100),R(100),WI(100),SN(100),ACT(50),T
1(50),T2(50),T3(50),T4(50),TT(50),FF(50),CC(50),A(
```

```
50),ACTR(50),ACTU(50),DM(50),DME(50),RM(50),RME(50
),AS(100),MOC(50),AT(10,10),MO(100),RT(50)
1390 DIM ABT(50),DO(10),X(12),UN(50),SPEC(50),EOD(
50),EODU(50),WDP(50),AWU(100),WDA(100),SPCN(100)
1400 SCREEN 2
1410 CLS
1420 LOCATE 10,21:PRINT "executing.............plea
se wait"
1430 GOSUB 4300
1440 LA$="EXAMPLE PROJECT"
1450 CALFL$="A:"+LA$+".CFL"
1460 OPEN CALFL$ AS 1 LEN=4
1470 FOR X = 1 TO DN
1480 C = X+ST-1
1490 GOSUB 1540
1500 F$(X)=DTE$
1510 NEXT X
1520 CLOSE #1
1530 GOTO 1670
1540 Z = 1
1550 FIELD Z,2 AS MD$, 2 AS YR$
1560 GET Z,C
1570 DT$=STR$(CVI(MD$))
1580 M = INT (CVI(MD$)/100)
1590 D$=RIGHT$(DT$,2)
1600 YR=CVI(YR$)
1610 P$ = D$
1620 Q$ =STR$(YR)
1630 K$= RIGHT$(Q$,2)
1640 J$ = STR$(M)
1650 DTE$ = P$+"/"+J$+"/"+K$
1660 RETURN
1670 LPRINT " I T E R A T I O N   N U M B E R ";I:L
PRINT
1680 LPRINT " DAY    DATE        ACTYNO.        DESCR
IPTION           NO.OF DAYS"
1690 LPRINT "
                    COMPLETED"
1700 FOR Q=1 TO DN:LPRINT :LPRINT :M=0
1710 GOSUB 1890:GOSUB 3370:GOSUB 2050
1720 IF Q=DN THEN GOSUB 3260
1730 NEXT Q
1740 FOR X=1 TO N
1750 IF C(X)=0 THEN 1770
1760 C(X)=C(X)+EOD(X)
1770 NEXT X
1780 FOR X=1 TO N:LPRINT X;TAB(6);F(X);TAB(12);T(X
);TAB(30);B$(X);TAB(46);C(X)
1790 NEXT X
1800 H$="DIST":CLS:LOCATE 10,21:PRINT "DO YOU WANT
 TO STORE (YES/NO)?":LINE INPUT STY$:IF STY$="YES"
 THEN 1810 ELSE 1880
1810 IF I=1 THEN 1820 ELSE 1850
1820 OPEN H$ FOR OUTPUT AS #15
```

```
1830 WRITE #15,I,N:FOR X=1 TO N:WRITE #15,C(X):NEX
T X
1840 CLOSE #15:GOTO 1880
1850 OPEN H$ FOR APPEND AS #15:WRITE #15,I,N
1860 FOR X=1 TO N:WRITE #15,C(X):NEXT X
1870 CLOSE #15
1880 END
1890 FOR Y=1 TO N:AC(Y)=0:NEXT Y:FOR Y=1 TO N:GOSU
B 1900:NEXT Y:RETURN
1900 IF E(Y) < = Q THEN GOSUB 1920
1910 RETURN
1920 IF G(Y) > Q THEN GOSUB 1940:GOTO 1930
1930 RETURN
1940 IF BW(Y)>0 THEN 2010
1950 IF EOD(Y) <> 0 THEN 1970
1960 GOTO 2010
1970 RA(Y)=RA(Y)+1:LPRINT Q;TAB(6);F$(Q);TAB(20);Y
;TAB(34);B$(Y);TAB(58);RA(Y)
1980 IF RA(Y) > = CA(Y)+EOD(Y) THEN LPRINT "ACTIVI
TY NO";Y;"COMPLETED.DURATION IS";CA(Y)+EOD(Y);"DAYS":
RETURN
1990 LPRINT "ACTIVITY";Y;"IS DELAYED DUE TO END OF
 ACTIVITY DELAY"
2000 RETURN
2010 RA(Y)=RA(Y)+1:LPRINT Q;TAB(6);F$(Q);TAB(20);Y
;TAB(34);B$(Y);TAB(58);RA(Y)
2020 M=M+1:AC(M)=Y
2030 RETURN
2040 PRINT:IF RA(Y) > CA(Y) THEN RETURN
2050 FOR R=1 TO M
2060 IF BW(AC(R)) = < 0 THEN 2260
2070 IF AW(AC(R))-BW(AC(R))<.25 THEN 2210
2080 IF AW(AC(R))-BW(AC(R)) <.5 THEN 2170
2090 C(AC(R))=RA(AC(R)) -(.5):CA(AC(R))=C(AC(R))
2100 IF EOD(AC(R))=0 THEN LPRINT "ACTIVITY";AC(R)
;"IS COMPLETED.DURATION IS";C(AC(R));"DAYS"
2110 IF EOD(AC(R)) <> 0 THEN 2130 PRINT
2120 FOR X=1 TO N:IF T(AC(R))=F(X) THEN GOSUB 2140
:NEXT X
2130 BW(AC(R))=0:GOTO 2320
2140 PRINT "AVAILABLE W.D FOR ACTY";X;"IS";.5:AW(X
)=.5:BW(X)=BW(X)-.5
2150 RED(X)=BW(X)
2160 RETURN
2170 C(AC(R))=RA(AC(R))
2180 BW(AC(R))=0
2190 IF EOD(AC(R))=0 THEN LPRINT "ACTY";AC(R);"IS
COMPLETED.DURATION IS";RA(AC(R));"DAYS"
2200 CA(AC(R))=C(AC(R)):GOTO 2320
2210 BW(AC(R))=RED(AC(R))-AW(AC(R))
2220 RED(AC(R))=BW(AC(R)):PRINT "BALANCE DURATION
FOR ACTIVITY";AC(R);"IS";BW(AC(R));"DAYS"
2230 IF BW(AC(R)) > =.25 THEN 2280
2240 IF BW(AC(R)) < 0 THEN 2260
```

```
2250 IF AW(AC(R)) < .75 THEN 2280
2260 IF EOD(AC(R))=0 THEN 2310
2270 C(AC(R))=RA(AC(R)):CA(AC(R))=C(AC(R)):BW(AC(R
))=0:LPRINT :LPRINT "ACTIVITY";AC(R);"IS COMPLETED.
THE DURATION IS";RA(AC(R));"DAYS":GOTO 2320
2280 IF RA(AC(R))=C(AC(R)) THEN 2300
2290 IF RA(AC(R)) < C(AC(R)) THEN 2320
2300 C(AC(R))=RA(AC(R))+BW(AC(R)):GOTO 2320
2310 BW(AC(R))=0:C(AC(R))=RA(AC(R)):IF EOD(AC(R))=
0 THEN 2270
2320 NEXT R
2330 FOR R=1 TO M:IF RA(AC(R)) < CA(AC(R)) THEN 23
50
2340 GOTO 2470
2350 NEXT R
2360 FOR X=1 TO M
2370 IF G(AC(X)) < Q+1 THEN GOSUB 2400
2380 NEXT X
2390 RETURN
2400 IF BW(AC(X)) = 0 THEN RETURN
2410 IF BW(AC(X)) < 0 THEN RETURN
2420 IF BW(AC(X)) > 0 THEN G(AC(X))=G(AC(X))+.75
2430 FOR O=1 TO N
2440 IF T(AC(X))=F(O) THEN E(O)=E(O)+.5
2450 NEXT O
2460 RETURN
2470 GOSUB 2540
2480 FOR R=1 TO M
2490 IF BW(AC(R)) < = 0 THEN 2500 ELSE 2510
2500 REM
2510 CA(AC(R))=C(AC(R))
2520 NEXT R
2530 RETURN
2540 FOR X=1 TO N:E(X)=0:G(X)=0:A(X)=0:NEXT X
2550 FOR Z =1 TO N-1
2560 J=Z
2570 FOR  X=Z+1 TO N
2580 IF F(X)>F(J) THEN 2620
2590 IF F(X)<F(J) THEN 2610
2600 IF T(X)>T(J) THEN 2620
2610 J=X
2620 NEXT  X
2630 IF J=Z THEN 2760
2640 H(1)=F(Z)
2650 H(2)=T(Z)
2660 H(3)=C(Z)
2670 H$(4)=B$(Z)
2680 F(Z)=F(J)
2690 T(Z)=T(J)
2700 C(Z)=C(J)
2710 B$(Z)=B$(J)
2720 F(J)=H(1)
2730 T(J)=H(2)
2740 C(J)=H(3)
```

```
2750 B$(J)=H$(4)
2760 NEXT  Z
2770 E(1)=1
2780 FOR X=1 TO N
2790 C(X)=C(X)+EOD(X)
2800 NEXT X
2810 FOR  X=1 TO N
2820 E(X)=E(X)+C(X)
2830 IF X=N THEN 2910
2840 FOR  D=X+1 TO N
2850 IF F(D)=F(1) THEN E(D)=1
2860 IF T(X) <>F(D) THEN 2890
2870 IF E(D)>E(X) THEN 2890
2880 E(D) =E(X)
2890 NEXT  D
2900 NEXT  X
2910 P=0
2920 FOR X=1 TO N
2930 IF P>E(X) THEN 2950
2940 P=E(X)
2950 NEXT  X
2960 FOR  X=1 TO N
2970 L(X)=P
2980 NEXT  X
2990 FOR Z=1 TO N
3000 X=N-Z+1
3010 FOR  D=1 TO N-Z
3020 IF F(X) <>T(D) THEN 3050
3030  IF L(X)-C(X)>L(D) THEN 3050
3040 L(D)=L(X)-C(X)
3050 NEXT  D
3060 NEXT  Z
3070 FOR  X=1 TO N
3080 A(X)=L(X)-E(X)
3090 NEXT X
3100 C1=L(N)-1
3110 FOR  X=1 TO N
3120 E(X)=E(X)-C(X)
3130 L(X)=L(X)-C(X)
3140 G(X)=E(X)+C(X)
3150 J(X)=L(X)+C(X)
3160 NEXT  X
3170 FOR X=1 TO N
3180 IF EOD(X)=0 THEN 3200
3190 C(X)=C(X)-EOD(X)
3200 NEXT X
3210 FOR X=1 TO M:IF G(AC(X)) < Q+1 THEN GOSUB 330
0
3220 NEXT X
3230 FOR X=1 TO M
3240 LPRINT AC(X),E(AC(X)),L(AC(X)),G(AC(X)),J(AC(
X)):NEXT X
3250 RETURN
3260 FOR R=1 TO M
```

```
3270 C(AC(R))=RA(AC(R))+BW(AC(R)):RR=INT(10©0+.5):
N2=INT(RR*C(AC(R))+.5):C(AC(R))=N2/RR
3280 NEXT R
3290 RETURN
3300 IF BW(AC(X)) = 0 THEN RETURN
3310 IF BW(AC(X)) < 0 THEN RETURN
3320 IF BW(AC(X)) > 0 THEN G(AC(X))=G(AC(X))+.75
3330 FOR O=1 TO N
3340 IF T(AC(X))=F(O) THEN E(O)=E(O)+.5
3350 NEXT O
3360 RETURN
3370 FOR Y=1 TO M
3380 IF TEM(Q) < 0 THEN WDT(AC(Y))=(1-T1(AC(Y))):G
OTO 3430
3390 IF TEM(Q) < 5 THEN WDT(AC(Y))=(1-T2(AC(Y))):GOTO
3430
3400 IF TEM(Q) < 15 THEN WDT(AC(Y))=(1-T3(AC(Y))):
GOTO 3430
3410 IF TEM(Q) > 25 THEN WDT(AC(Y))=(1-T4(AC(Y))):
GOTO 3430
3420 WDT(AC(Y))=1
3430 IF R(Q) > 5 THEN WDT(AC(Y))=WDT(AC(Y))*(1-CC(
AC(Y)))
3440 IF SN(Q) > 10 THEN WDT(AC(Y))=WDT(AC(Y))*(1-T
T(AC(Y)))
3450 WDT(AC(Y))=1-WDT(AC(Y))
3460 NEXT Y:IF M=0 THEN 3640
3470 IF AS(Q)=0 THEN 3640
3480 FOR AR= 1 TO AS(Q):RANDOMIZE(AR*I*Q):RN(AR)=(
RND(AR*I*Q))*M
3490 RR=INT(10©0+.5)
3500 N2=INT(RR*RN(AR)+.5)
3510 RN(AR)=N2/RR
3520 IF RN(AR) < 1 THEN AR=AR-1:GOTO 3540
3530 AB(AR)=RN(AR)
3540 NEXT AR
3550 FOR R=1 TO M:FOR AR=1 TO AS(Q)
3560 IF R=AB(AR) THEN ABT(R)=ABT(R)+1
3570 NEXT AR:NEXT R
3580 FOR R=1 TO M
3590 IF ABT(R)=0 THEN 3630
3600 IF ABT(R)  = 1 THEN WDA(AC(R))=MOC(AC(R))
3610 IF ABT(R) > = 2 THEN WDA(AC(R))=MTC(AC(R))
3620 ABT(R)=0
3630 NEXT R
3640 FOR X=1 TO ZZ:SPCN(X)=SP(X):NEXT X
3650 FOR X=1 TO ZZ:FOR R=1 TO M:IF ZN(AC(R))=0 THE
N 3670
3660 IF ZN(AC(R))=X THEN SPCN(X)=SPCN(X)-SPR(AC(R)
)
3670 NEXT R
3680 NEXT X
3690 FOR X=1 TO ZZ:IF SPCN(X)<0 THEN GOSUB 3710
3700 NEXT X:GOTO 3770
```

```
3710 SC(X)=0:FOR R=1 TO M:IF ZN(AC(R))=X THEN SC(X)=SC
(X)+1:AT(X,SC(X))=AC(R)
3720 NEXT R
3730 NOS=0
3740 FOR R=1 TO SC(X):IF A(AT(X,R))>0 THEN WDS(AT(
X,R))=1:SPCN(X)=SPCN(X)+SPR(AT(X,R)):IF SPCN(X)> =
 0 THEN RETURN ELSE 3760
3750 NOS=NOS+1:CRI(NOS)=AT(X,R)
3760 NEXT R;RETURN
3770 FOR CR=1 TO NOS:WDS(CRI(CR))=1-(1/NOS)
3780 NEXT CR:NOS=0
3790 FOR R=1 TO M:FOR Y=1 TO RER:IF AC(R)=ACTR(Y)
THEN GOSUB 3820:GOTO 3810
3800 NEXT Y
3810 NEXT R:GOTO 3840
3820 WDR(AC(R))=RM(ACTR(Y))
3830 RETURN
3840 FOR R=1 TO M:FOR Y=1 TO DC
3850 IF AC(R)=ACTU(Y) THEN GOSUB 3880:GOTO 3870
3860 NEXT Y
3870 NEXT R:GOTO 3890
3880 WDD(AC(R))=DM(ACTU(Y)):RETURN
3890 REM
3900 X(YE)=.8
3910 X(YE+1)=.8
3920 X(YE+2)=.9000001
3930 X(YE+3)=.9000001
3940 X(YE+4)=.9000001
3950 IF MO(Q)=YE THEN X=X(YE)
3960 IF MO(Q)=YE+1 THEN X=X(YE+1)
3970 IF MO(Q)=YE+2 THEN X=X(YE+2)
3980 IF MO(Q)=YE+3 THEN X=X(YE+3)
3990 Y = 1.15 -( .15*X)
4000 FOR R=1 TO M:FOR X=1 TO ALU
4010 IF AC(R)=ACTL(X) THEN GOSUB 4270 :GOTO 4030
4020 NEXT X
4030 NEXT R
4040 FOR R=1 TO M
4050 IF WDT(AC(R))=1 THEN AW(AC(R))=0:GOTO 4190
4060 IF WDA(AC(R))=1 THEN AW(AC(R))=0:GOTO 4190
4070 IF WDS(AC(R))=1 THEN AW(AC(R))=0:GOTO 4190
4080 IF WDR(AC(R))=1 THEN AW(AC(R))=0:GOTO 4190
4090 IF WDD(AC(R))=1 THEN AW(AC(R))=0:GOTO 4190
4100 IF WDP(AC(R))=1 THEN AW(AC(R))=0:GOTO 4190
4110 IF Y=0 THEN AW(AC(R))=0:GOTO 4190
4120 AW(AC(R))=1+WDT(AC(R))+WDA(AC(R))+WDS(AC(R))+
WDR(AC(R))+WDD(AC(R))+WDP(AC(R))
4130 AWU(AC(R))=(1-(((AW(AC(R))-WDT(AC(R)))*(AW(AC
(R))-WDA(AC(R)))*(AW(AC(R))-WDS(AC(R)))*(AW(AC(R))
-WDR(AC(R)))*(AW(AC(R))-WDD(AC(R)))*(AW(AC(R))-WDP
(AC(R))))/(AW(AC(R))^6)))*AW(AC(R))+1
4140 IF AW(AC(R))-AWU(AC(R)) <.1 THEN 4160
4150 AW(AC(R))=AWU(AC(R)):GOTO 4130
4160 AW(AC(R))=1/AWU(AC(R))
```

```
4170 AW(AC(R))=AW(AC(R))*Y
4180 PRINT "AVAILABLE WD FOR ACTY";AC(R);"IS";AW(A
C(R))
4190 NEXT R
4200 FOR R=1 TO M:WDT(AC(R))=0:WDS(AC(R))=0:WDR(AC
(R))=0:WDD(AC(R))=0:WDP(AC(R))=0:AWU(AC(R))=0:NEXT
 R
4210 FOR R=1 TO M
4220 RR=INT(10©1+.5)
4230 N2=INT(RR*AW(AC(R))+.5)
4240 AW(AC(R))=N2/RR
4250 NEXT R
4260 RETURN
4270 FOR L=1 TO LU
4280 IF Q=LU(L) THEN WDP(AC(R))=PROD(ACTL(X)) ELSE
 NEXT L
4290 RETURN
4300 M$="OP1"
4310 OPEN M$ FOR INPUT AS #2
4320 INPUT #2,DN,N,NN,ST,EN
4330 CLOSE #2
4340 H$="OP4":OPEN H$ FOR INPUT AS #6:INPUT #6,I
4350 FOR X=1 TO DN:INPUT #6,TEM(X),R(X),SN(X)
4360 NEXT X:CLOSE #6
4370 H$="OP5"
4380 OPEN H$ FOR INPUT AS #7:INPUT #7,WI:WRITE #7,
WI
4390 FOR X = 1 TO WI:INPUT #7,ACT(X):WRITE #7,ACT(
X):NEXT X:
4400 FOR X = 1 TO WI:INPUT #7,T1(ACT(X)),T2(ACT(X)
),T3(ACT(X)),T4(ACT(X)),TT(ACT(X)),CC(ACT(X))
4410 NEXT X:CLOSE #7
4420 M$="OP1"
4430 OPEN M$ FOR INPUT AS #2
4440 INPUT #2,DN,N,NN,ST,EN
4450 FOR X=1 TO N:INPUT #2,F(X),T(X),B$(X),C(X):CA
(X)=C(X):NEXT X:FOR X=1 TO N:INPUT #2,E(X),L(X),G(
X),J(X),A(X):G(X)=G(X)+1:J(X)=J(X)+1:NEXT X
4460 CLOSE #2
4470 H$="OP7":OPEN H$ FOR INPUT AS #8
4480 INPUT #8,I:FOR X=1 TO N:INPUT #8,RED(X):BW(X)
=RED(X):NEXT X
4490 INPUT #8,RER:FOR X=1 TO RER:INPUT #8,ACTR(X):
NEXT X:FOR X=1 TO RER:INPUT #8,RM(ACTR(X)),RME(ACT
R(X)):NEXT X
4500 INPUT #8,DC:FOR X=1 TO DC:INPUT #8,ACTU(X):NE
XT X:FOR X=1 TO DC:INPUT #8,DM(ACTU(X)),DME(ACTU(X
))
4510 NEXT X:INPUT #8,SPE:FOR X=1 TO SPE:INPUT #8,S
PEC(X),UN(SPEC(X)):NEXT X:CLOSE #8
4520 FOR X=1 TO N
4530 EOD(X)=RME(X)+DME(X)+UN(X)
4540 NEXT X
4550 FOR X=1 TO N:IF EOD(X)=0 THEN 4580
```

```
4560 RR=INT(10©0+.5):N2=INT(RR*EOD(X)+.5)
4570 EOD(X)=N2/RR
4580 NEXT X
4590 H$="OP10":OPEN H$ FOR INPUT AS #10:INPUT #10,YE,C
A
4600 FOR X=1 TO DN:INPUT #10,AS(X):NEXT X
4610 FOR Y=1 TO N:INPUT #10,MOC(Y),MTC(Y):NEXT Y
4620 FOR Y=YE TO YE+4:INPUT #10,EM(Y):NEXT Y
4630 FOR Y=1 TO DN:INPUT #10,MO(Y):NEXT Y
4640 CLOSE #10
4650 H$="OP12":OPEN H$ FOR INPUT AS #12
4660 INPUT #12,ZZ,SC:FOR X=1 TO ZZ:INPUT #12,SP(X)
:NEXT X
4670 FOR X=1 TO SC:INPUT #12,ACTS(X),ZN(ACTS(X)),S
PR(ACTS(X)):NEXT X
4680 CLOSE #12
4690 M$="OP14":OPEN M$ FOR INPUT AS #14
4700 INPUT #14,LU,ALU
4710 FOR X=1 TO LU:INPUT #14,LU(X):NEXT X
4720 FOR X=1 TO ALU:INPUT #14,ACTL(X),PROD(ACTL(X)
)
4730 NEXT X
4740 CLOSE #14
4750 FOR X=1 TO N:IF EOD(X)=0 THEN 4830
4760 EOD(X)=EOD(X)+C(X)
4770 EODU(X)=(1-(((EOD(X)-RME(X))*(EOD(X)-DME(X))*(EOD
(X)-UN(X)))/(EOD(X)©3)))*EOD(X)+C(X)
4780 IF EOD(X)-EODU(X) < .1 THEN 4800
4790 EOD(X)=EODU(X):GOTO 4770
4800 EOD(X)=EODU(X)
4810 EOD(X)=EOD(X)-C(X):LPRINT "END O
F ACTY DELAY FOR ACTY";X;"IS";EOD(X)
4820 RR=INT(10©0+.5):N2=INT(RR*EOD(X)+.5):EOD(X)=N2/RR
4830 NEXT X
4840 RETURN
```

```
100 REM **************************************************
110 REM *****                                        *****
120 REM *****      PRODUF COMPUTER MODEL STEP 4      *****
130 REM *****                                        *****
140 REM **************************************************
150 DIM CS(50,40),CA(50,40),RA(100),CC(50,50),I(50),CRI
T(50,15),C(50),F(50),T(50),E(50),L(50),G(50),J(50),C1(5
0),JA(50),B$(50),A(50)
160 H$="DIST"
170 OPEN H$ FOR INPUT AS #1
180 FOR X=1 TO 30:INPUT #1,I(X),N
190 FOR Y=1 TO N
200 INPUT #1,CA(X,Y)
210 NEXT Y
220 NEXT X
230 CLOSE #1
240 FOR X=1 TO N
250 FOR Y=1 TO 30
260 CS(X,Y)=CA(Y,X)
270 NEXT Y
280 NEXT X
290 FOR X=1 TO N
300 FOR I=1 TO 29
310 FOR J=1 TO 29
320 A=CS(X,J)
330 B=CS(X,J+1)
340 IF A < = B THEN 370
350 LET CS(X,J)=B
360 LET CS(X,J+1)=A
370 NEXT J
380 NEXT I
390 FOR R=1 TO 30
400 CA(X,R)=CS(X,R)
410 NEXT R
420 NEXT X
430 GOTO 870
440 LPRINT TAB(5);"S I M U L A T E D  A C T I V I T Y
D U R A T I O N S ":LPRINT
450 LPRINT :LPRINT :LPRINT
460 LPRINT  TAB(5);"ACTIVITY              SIMULATED DURATI
ONS(ASCENDING ORDER)"
470 LPRINT :LPRINT TAB(7);"NO     1    2     3    4    5
    6     7     8     9    10"
480 LPRINT :LPRINT
490 FOR X=1 TO 36
500 IF X= >10 THEN 520
510 LPRINT TAB(7);X;;:GOTO 530
520 LPRINT TAB(6);X;;
530 FOR Y=1 TO 10
540 LPRINT USING "###.#";CA(X,Y);
550 NEXT Y
560 LPRINT:LPRINT
570 IF X=24 THEN LINE INPUT GG$
580 NEXT X
```

```
590 LINE INPUT GG$
600 LPRINT  TAB(5);"ACTIVITY                SIMULATED DURATI
ONS(ASCENDING ORDER)"
610 LPRINT :LPRINT TAB(7);"NO     11      12     13     14
  15     16     17     18     19     20"
620 LPRINT :LPRINT
630 FOR X=1 TO 36
640 IF X= >10 THEN 660
650 LPRINT TAB(7);X;;:GOTO 670
660 LPRINT TAB(6);X;;
670 FOR Y=11 TO 20
680 LPRINT USING "####.#";CA(X,Y);
690 NEXT Y
700 LPRINT:LPRINT
710 IF X=24 THEN LINE INPUT GG$
720 NEXT X
730 LINE INPUT GG$
740 LPRINT  TAB(5);"ACTIVITY                SIMULATED DURATI
ONS(ASCENDING ORDER)"
750 LPRINT :LPRINT TAB(7);"NO     21      22     23     24
  25     26     27     28     29     30"
760 LPRINT :LPRINT
770 FOR X=1 TO 36
780 IF X= >10 THEN 800
790 LPRINT TAB(7);X;;:GOTO 810
800 LPRINT TAB(6);X;;
810 FOR Y=21 TO 30
820 LPRINT USING "####.#";CA(X,Y);
830 NEXT Y
840 LPRINT:LPRINT
850 IF X=24 THEN LINE INPUT GG$
860 NEXT X
870 PRINT "GIVE ANY NUMBER BETWEEN 1 AND 100 FOR RANDOM
IZATION PURPOSE"
880 INPUT A
890 FOR X=1 TO 50
900 FOR Y=1 TO N
910 RANDOMIZE(A*Y)
920 RA(Y)=RND(A*X*Y)
930 FOR Z=1 TO 30
940 IF RA(Y) < = (.033)*Z THEN CC(X,Y)=CA(Y,Z):GOTO 960
950 NEXT Z
960 NEXT Y
970 NEXT X
980 H$="SIMDU"
990 OPEN H$ FOR OUTPUT AS #6
1000 FOR X=1 TO 50
1010 FOR Y=1 TO N
1020 WRITE #6,CC(X,Y)
1030 NEXT Y
1040 NEXT X
1050 CLOSE #6
1060 CLEAR
1070 DIM CS(50,40),CA(50,40),RA(100),CC(50,50),I(50),CR
```

```
IT(50,20),C(50),F(50),T(50),E(50),L(50),G(50),J(50),C1(
50),JA(50),B$(50),A(50)
1080 H$="SIMDU"
1090 OPEN H$ FOR INPUT AS #6
1100 FOR X=1 TO 50
1110 FOR Y=1 TO 36
1120 INPUT #6,CC(X,Y)
1130 NEXT Y:NEXT X:CLOSE #6
1140 M$="OP1"
1150 OPEN M$ FOR INPUT AS #2
1160 INPUT #2,DN,N,ST,EN,DN:N=36
1170 FOR X=1 TO N
1180 INPUT #2,F(X),T(X),B$(X),C(X)
1190 NEXT X
1200 CLOSE #2
1210 FOR I=1 TO 50
1220 FOR X=1 TO N
1230 C(X)=CC(I,X)
1240 NEXT X
1250 E(1)=1
1260 FOR  X=1 TO N
1270 E(X)=E(X)+C(X)
1280 IF X=N THEN 1360
1290 FOR  D=X+1 TO N
1300 IF F(D)=F(1) THEN E(D)=1
1310 IF T(X) <>F(D) THEN 1340
1320 IF E(D)>E(X) THEN 1340
1330 E(D) =E(X)
1340 NEXT  D
1350 NEXT  X
1360 P=0
1370 FOR X=1 TO N
1380 IF P>E(X) THEN 1400
1390 P=E(X)
1400 NEXT  X
1410 FOR  X=1 TO N
1420 L(X)=P
1430 NEXT  X
1440 FOR Z=1 TO N
1450 X=N-Z+1
1460 FOR  D=1 TO N-Z
1470 IF F(X) <>T(D) THEN 1500
1480  IF L(X)-C(X)>L(D) THEN 1500
1490 L(D)=L(X)-C(X)
1500 NEXT  D
1510 NEXT  Z
1520 FOR  X=1 TO N
1530 A(X)=L(X)-E(X)
1540 NEXT X
1550 C1(I)=L(N)-1
1560 FOR  X=1 TO N
1570 E(X)=E(X)-C(X)
1580 L(X)=L(X)-C(X)
1590 G(X)=E(X)+C(X)-1
```

```
1600 J(X)=L(X)+C(X)-1
1610 NEXT  X
1620 LPRINT "THE COMPLETION TIME FOR ITERATION";I;"IS";
C1(I)
1630 LPRINT "CRITICAL ACTIVITIES FOR ITERATION";I;"ARE
GIVEN BELOW:"
1640 J(I)=0
1650 FOR X=1 TO N
1660 IF A(X)=0 THEN GOSUB 1810
1670 NEXT X:LPRINT "TOTAL CRITICAL ACTIVITIES IN ITERAT
ION";I;"IS";JA(I)
1680 FOR X=1 TO N
1690 C(X)=0:E(X)=0:L(X)=0:G(X)=0:J(X)=0:A(X)=0:NEXT X
1700 NEXT I
1710 END
1720 H$="DURA"
1730 OPEN H$ FOR OUTPUT AS #3
1740 FOR I=1 TO N
1750 WRITE #3,C1(I),J(I)
1760 FOR X=1 TO J(I)
1770 WRITE #3,CRIT(I,X)
1780 NEXT X
1790 NEXT I
1800 CLOSE #3
1810 JA(I)=JA(I)+1:CRIT(I,JA(I))=X:LPRINT I,CRIT(I,JA(I
))
1820 RETURN
```

-----------------PROJECT SCHEDULE STATUS REPORT--------------

STRATEGIC SCHEDULE

PROJECT---EXAMPLE PROJECT

CALENDAR DATE REPORT

PRED EVE	SUCC EVE	ACTIVITY DESCRIPTON	DURA TION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	TF	
1	3	CLEAR GRADE	7	01/ 5/84	01/ 5/84	09/ 5/84	09/ 5/84	0	*
3	11	START ELEC.SY	15	10/ 5/84	16/ 5/84	30/ 5/84	05/ 6/84	4	
3	13	WATER SYSTEM	27	10/ 5/84	10/ 5/84	15/ 6/84	15/ 6/84	0	*
11	13	ELEC.SUPPLY	8	31/ 5/84	06/ 6/84	11/ 6/84	15/ 6/84	4	
13	17	PILES & CAPS	20	18/ 6/84	18/ 6/84	13/ 7/84	13/ 7/84	0	*
13	25	EXCA.FOOTINGS	13	18/ 6/84	30/ 7/84	04/ 7/84	16/ 8/84	30	
17	18	GRADE BEAMS	10	16/ 7/84	16/ 7/84	27/ 7/84	27/ 7/84	0	*
18	29	PREPARE &POUR	23	30/ 7/84	30/ 7/84	30/ 8/84	30/ 8/84	0	*
25	29	FLOOR SLABS	10	05/ 7/84	17/ 8/84	18/ 7/84	30/ 8/84	30	
29	33	ERECT ST.STEEL	20	31/ 8/84	31/ 8/84	27/ 9/84	27/ 9/84	0	*
33	37	ROOF SYSTEM	16	28/ 9/84	28/ 9/84	19/ 10/84	19/ 10/84	0	*
37	47	BOILER INSTALL	35	22/ 10/84	20/ 12/84	07/ 12/84	07/ 2/85	43	
37	52	HEAT & VENT.	55	22/ 10/84	22/ 11/84	07/ 1/85	07/ 2/85	23	
37	56	ELE.SYS	78	22/ 10/84	22/ 10/84	07/ 2/85	07/ 2/85	0	*
47	58	DUMMY	0	10/ 12/84	08/ 2/85	07/ 12/84	07/ 2/85	43	
52	58	DUMMY	0	08/ 1/85	08/ 2/85	07/ 1/85	07/ 2/85	23	
56	58	DUMMY	0	08/ 2/85	08/ 2/85	07/ 2/85	07/ 2/85	0	*

58	60	ER.STL	10	08/ 2/85	08/ 2/85	21/ 2/85	21/ 2/85	0	*
58	80	FLAG POLE	10	08/ 2/85	24/ 5/85	21/ 2/85	06/ 6/85	74	
60	61	EX.MASONRY	10	22/ 2/85	22/ 2/85	07/ 3/85	07/ 3/85	0	*
61	66	ELEC ROUGH	14	08/ 3/85	08/ 3/85	27/ 3/85	27/ 3/85	0	*
61	67	PIPING	14	08/ 3/85	08/ 3/85	27/ 3/85	27/ 3/85	0	*
61	68	CLOSE IN BLDG	5	08/ 3/85	28/ 3/85	14/ 3/85	03/ 4/85	14	
66	67	DUMMY	0	28/ 3/85	28/ 3/85	27/ 3/85	27/ 3/85	0	*
66	76	PULL WIRE	10	28/ 3/85	25/ 4/85	10/ 4/85	09/ 5/85	20	
67	68	LATH	5	28/ 3/85	28/ 3/85	03/ 4/85	03/ 4/85	0	*
68	70	PLASTER	15	04/ 4/85	04/ 4/85	24/ 4/85	24/ 4/85	0	*
70	80	FINISH PAINT	30	25/ 4/85	25/ 4/85	06/ 6/85	06/ 6/85	0	*
76	80	COMPLETE ERECTION	20	11/ 4/85	10/ 5/85	09/ 5/85	06/ 6/85	20	

* -- INDICATES CRITICAL ACTIVITY

PROJECT DURATION IS 285 DAYS

-----------------PROJECT SCHEDULE STATUS REPORT---------------

PROJECT----EXAMPLE PROJECT

TACTICAL SCHEDULE

CALENDAR DATE REPORT

PRED EVE	SUCC EVE	ACTIVITY DESCRIPTON	DURATION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	TF	
0	1	CLEAR SITE	3	01/ 5/84	01/ 5/84	03/ 5/84	03/ 5/84	0	*
1	2	SURVEY&L.O	2	04/ 5/84	04/ 5/84	07/ 5/84	07/ 5/84	0	*
2	3	ROUGH GRADE	2	08/ 5/84	08/ 5/84	09/ 5/84	09/ 5/84	0	*
3	4	DRILL WELL	15	10/ 5/84	10/ 5/84	30/ 5/84	30/ 5/84	0	*
3	6	FOUND.WELL	4	10/ 5/84	11/ 5/84	15/ 5/84	16/ 5/84	1	
3	9	EXCA.FOR SEWAR.	10	10/ 5/84	16/ 5/84	23/ 5/84	29/ 5/84	4	
3	10	EXCA.MANHO	1	10/ 5/84	29/ 5/84	10/ 5/84	29/ 5/84	13	
3	12	O.H.POLE	6	10/ 5/84	01/ 6/84	17/ 5/84	08/ 6/84	16	
4	5	INSTALL W.P	2	31/ 5/84	31/ 5/84	01/ 6/84	01/ 6/84	0	*
5	8	U.G.W.P	8	04/ 6/84	04/ 6/84	13/ 6/84	13/ 6/84	0	*
6	7	ERECT W.T	10	16/ 5/84	17/ 5/84	29/ 5/84	30/ 5/84	1	
7	8	TANK PIPE	10	30/ 5/84	31/ 5/84	12/ 6/84	13/ 6/84	1	
8	13	CONNECT PIPING	2	14/ 6/84	14/ 6/84	15/ 6/84	15/ 6/84	0	*
9	11	INSTALL SEWAR	5	24/ 5/84	30/ 5/84	30/ 5/84	05/ 6/84	4	
10	11	INSTALL M/H	5	11/ 5/84	30/ 5/84	17/ 5/84	05/ 6/84	13	
11	12	INSTALL ELEC.DUCT	3	31/ 5/84	06/ 6/84	04/ 6/84	08/ 6/84	4	
12	13	PULL IN P/FEED	5	05/ 6/84	11/ 6/84	11/ 6/84	15/ 6/84	4	

13	14	BLDG L/O	1	18/ 6/84	18/ 6/84	18/ 6/84	18/ 6/84	0	*
13	23	EXCA.FOR OFF	3	18/ 6/84	01/ 8/84	20/ 6/84	03/ 8/84	32	
14	15	DRIVE &POUR PILE	10	19/ 6/84	19/ 6/84	02/ 7/84	02/ 7/84	0	*
15	16	EXCA.PLA M/H	5	03/ 7/84	03/ 7/84	09/ 7/84	09/ 7/84	0	*
16	17	POUR PILE CAP	5	10/ 7/84	10/ 7/84	16/ 7/84	16/ 7/84	0	*
17	18	FORM AND POUR	10	17/ 7/84	17/ 7/84	30/ 7/84	30/ 7/84	0	*
18	19	BACKFILL	3	31/ 7/84	31/ 7/84	02/ 8/84	02/ 8/84	0	*
18	21	FORM & POUR R/L	5	31/ 7/84	10/ 8/84	06/ 8/84	17/ 8/84	8	
18	22	FORM & POUR T/L	5	31/ 7/84	10/ 8/84	06/ 8/84	17/ 8/84	8	
19	20	U/G PLUMB	5	03/ 8/84	03/ 8/84	09/ 8/84	09/ 8/84	0	*
20	22	U/G CONDUIT	5	10/ 8/84	10/ 8/84	17/ 8/84	17/ 8/84	0	*
21	22	DUMMY	0	07/ 8/84	20/ 8/84	06/ 8/84	17/ 8/84	8	
22	29	FORM & POUR	10	20/ 8/84	20/ 8/84	31/ 8/84	31/ 8/84	0	*
23	24	SPREAD PLOT	3	21/ 6/84	06/ 8/84	25/ 6/84	08/ 8/84	32	
24	25	FORM&POUR	6	26/ 6/84	09/ 8/84	03/ 7/84	17/ 8/84	32	
25	26	B/F&COMPACT	1	04/ 7/84	20/ 8/84	04/ 7/84	20/ 8/84	32	
26	27	U/G PLUMB	3	05/ 7/84	21/ 8/84	09/ 7/84	23/ 8/84	32	
27	28	U/G CONDUIT	[illegible]	10/ 7/84	24/ 8/84	12/ 7/84	28/ 8/84	32	
28	29	FORM&POUR	3	13/ 7/84	29/ 8/84	17/ 7/84	31/ 8/84	32	

* - INDICATES CRITICAL ACTIVITY

PROJECT DURATION IS 88 DAYS

------------------PROJECT SCHEDULE STATUS REPORT-----------------

PROJECT----EXAMPLE PROJECT

TACTICAL SCHEDULE

WORKDAY REPORT

PRED EVE	SUCC EVE	ACTIVITY DESCRIPTON	DURA TION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	TF	
0	1	CLEAR SITE	3	1	1	3	3	0	*
1	2	SURVEY&L.O	2	4	4	5	5	0	*
2	3	ROUGH GRADE	2	6	6	7	7	0	*
3	4	DRILL WELL	15	8	8	22	22	0	*
3	6	FOUND.WELL	4	8	9	11	12	1	
3	9	EXCA.FOR SEWAR.	10	8	12	17	21	4	
3	10	EXCA.MANHO	1	8	21	8	21	13	
3	12	O.H.POLE	6	8	24	13	29	16	
4	5	INSTALL W.P	2	23	23	24	24	0	*
5	8	U.G.W.P	8	25	25	32	32	0	*
6	7	ERECT W.T	10	12	13	21	22	1	
7	8	TANK PIPE	10	22	23	31	32	1	
8	13	CONNECT PIPING	2	33	33	34	34	0	*
9	11	INSTALL SEWAR	5	18	22	22	26	4	
10	11	INSTALL M/H	5	9	22	13	26	13	
11	12	INSTALL ELEC.DUCT	3	23	27	25	29	4	
12	13	PULLIN P/FEED	5	26	30	30	34	4	

13	14	BLDG L/O	1	35	35	35	35	0	*
13	23	EXCA.FOR OFF	3	35	67	37	69	32	
14	15	DRIVE &POUR PILE	10	36	36	45	45	0	*
15	16	EXCA.PLA W/H	5	46	46	50	50	0	*
16	17	POUR PILE CAP	5	51	51	55	55	0	*
17	18	FORM AND POUR	10	56	56	65	65	0	*
18	19	BACKFILL	3	66	66	68	68	0	*
18	21	FORM & POUR R/L	5	66	74	70	78	8	
18	22	FORM & POUR T/L	5	66	74	70	78	8	
19	20	U/G PLUMB	5	69	69	73	73	0	*
20	22	U/G CONDUIT	5	74	74	78	78	0	*
21	22	DUMMY	0	71	79	70	78	8	
22	29	FORM & POUR	10	79	79	88	88	0	*
23	24	SPREAD PLOT	3	38	70	40	72	32	
24	25	FORM&POUR	6	41	73	46	78	32	
25	26	B/F&COMPACT	1	47	79	47	79	32	
26	27	U/G PLUMB	3	48	80	50	82	32	
27	28	U/G CONDUIT	3	51	83	53	85	32	
28	29	FORM&POUR	3	54	86	56	88	32	

* - INDICATES CRITICAL ACTIVITY

PROJECT DURATION IS 88 DAYS

PROJECT CALENDAR

1984

JANUARY

#	SUN	MON	TUE	WED	THU	FRI	SAT

FEBRUARY

#	SUN	MON	TUE	WED	THU	FRI	SAT

MARCH

#	SUN	MON	TUE	WED	THU	FRI	SAT

APRIL

#	SUN	MON	TUE	WED	THU	FRI	SAT

MAY

#	SUN	MON	TUE	WED	THU	FRI	SAT
(1)			1	2	3	4	
(5)		7	8	9	10	11	
(10)		14	15	16	17	18	
(15)		21	22	23	24	25	
(20)		28	29	30	31		

JUNE

#	SUN	MON	TUE	WED	THU	FRI	SAT
(24)						1	
(25)		4	5	6	7	8	
(30)		11	12	13	14	15	
(35)		18	19	20	21	22	
(40)		25	26	27	28	29	

JULY

#	SUN	MON	TUE	WED	THU	FRI	SAT
(45)		2	3	4	5	6	
(50)		9	10	11	12	13	
(55)		16	17	18	19	20	
(60)		23	24	25	26	27	
(65)		30	31				

AUGUST

#	SUN	MON	TUE	WED	THU	FRI	SAT
(67)				1	2	3	
(70)		6	7	8	9	10	
(75)		13	14		16	17	
(79)		20	21	22	23	24	
(84)		27	28	29	30	31	

SEPTEMBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(89)		3	4	5	6	7	
(94)		10	11	12	13	14	
(99)		17	18	19	20	21	
(104)		24	25	26	27	28	

OCTOBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(109)		1	2	3	4	5	
(114)		8	9	10	11	12	
(119)		15	16	17	18	19	
(124)		22	23	24	25	26	
(129)		29	30	31			

NOVEMBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(132)					1	2	
(134)		5	6	7	8	9	
(139)		12	13	14	15	16	
(144)		19	20	21	22	23	
(149)		26	27	28	29	30	

DECEMBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(154)		3	4	5	6	7	
(159)		410	11	12	13	14	
(164)		17	18	19	20	21	
(169)		24		26	27	28	
		31					

PROJECT CALENDAR

1985

JANUARY

#	SUN	MON	TUE	WED	THU	FRI	SAT
(173)			1	2	3	4	
(178)		7	8	9	10	11	
(183)		14	15	16	17	18	
(188)		21	22	23	24	25	
(193)		28	29	30	31		

FEBRUARY

#	SUN	MON	TUE	WED	THU	FRI	SAT
(197)						1	
(198)		4	5	6	7	8	
(203)		11	12	13	14	15	
(208)		18	19	20	21	22	
(213)		25	26	27	28		

MARCH

#	SUN	MON	TUE	WED	THU	FRI	SAT
(217)						1	
(218)		4	5	6	7	8	
(223)		11	12	13	14	15	
(228)		18	19	20	21	22	
(233)		25	26	27	28	29	

APRIL

#	SUN	MON	TUE	WED	THU	FRI	SAT
(238)		1	2	3	4	5	
(243)		8	9	10	11	12	
(248)		15	16	17	18	19	
(253)		22	23	24	25	26	
(258)		29	30				

MAY

#	SUN	MON	TUE	WED	THU	FRI	SAT
(260)				1	2	3	
(263)		6	7	8	9	10	
(268)		13	14	15	16	17	
(273)		20	21	22	23	24	
(278)		27	28	29	30	31	

JUNE

#	SUN	MON	TUE	WED	THU	FRI	SAT
(283)		3	4	5	6	7	
(288)		10	11	12	13	14	
(293)		17	18	19	20	21	
(298)		24	25	26	27	28	

JULY

#	SUN	MON	TUE	WED	THU	FRI	SAT
(303)		1	2	3	4	5	
(308)		8	9	10	11	12	
(313)		15	16	17	18	19	
(318)		22	23	24	25	26	
(323)		29	30	31			

AUGUST

#	SUN	MON	TUE	WED	THU	FRI	SAT
(326)					1	2	
(328)		5	6	7	8	9	
(333)		12	13	14		16	
(337)		19	20	21	22	23	
(342)		26	27	28	29	30	

SEPTEMBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(347)		2	3	4	5	6	
(352)		9	10	11	12	13	
(357)		16	17	18	19	20	
(362)		23	24	25	26	27	
(367)		30					

OCTOBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(368)			1	2	3	4	
(372)		7	8	9	10	11	
(377)		14	15	16	17	18	
(382)		21	22	23	24	25	
(387)		28	29	30	31		

NOVEMBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(391)						1	
(392)		4	5	6	7	8	
(397)		11	12	13	14	15	
(402)		18	19	20	21	22	
(407)		25	26	27	28	29	

DECEMBER

#	SUN	MON	TUE	WED	THU	FRI	SAT
(412)		2	3	4	5	6	
(417)		9	10	11	12	13	
(422)		16	17	18	19	20	
(427)		23	24		26	27	
(431)		30	31				
(433)							

E A S T   D A M

DAY	DATE	VOL.	CU.VOL.	CU.EL.
31	01/ 5/84	.120497	.120497	369.47
32	02/ 5/84	9.041999E-02	.210917	370.94
33	03/ 5/84	.081378	.292295	372.22

EAST DAM REACHED ELEVATION 372.22 ON 03/ 5/84 WHICH IS PROJECT DAY 33

C O N S T R U C T I O N   P R O G R E S S

DAY	DATE	WEST DAM LEVEL	EAST DAM LEVEL
34	04/ 5/84	374.26	372.22
35	05/ 5/84	374.26	372.22
36	06/ 5/84	374.26	372.22
37	07/ 5/84	374.74	372.22
38	08/ 5/84	375.27	372.22
39	09/ 5/84	375.27	374.01
40	10/ 5/84	375.66	374.01
41	11/ 5/84	375.77	374.01
42	12/ 5/84	376.1	374.01
43	13/ 5/84	376.1	374.01
44	14/ 5/84	376.63	374.01
45	15/ 5/84	377.14	374.01
46	16/ 5/84	377.14	375.83
47	17/ 5/84	377.68	375.83
48	18/ 5/84	378.21	375.83
49	19/ 5/84	378.21	375.83
50	20/ 5/84	378.21	375.83
51	21/ 5/84	378.21	375.83
52	22/ 5/84	378.37	375.83
53	23/ 5/84	378.79	375.83
54	24/ 5/84	379.11	375.83
55	25/ 5/84	379.11	376.78
56	26/ 5/84	379.28	376.78
57	27/ 5/84	379.51	376.78
58	28/ 5/84	379.84	376.78
59	29/ 5/84	379.84	378.37
60	30/ 5/84	380.38	378.37
61	31/ 5/84	380.86	378.37
62	01/ 6/84	381.23	378.37
63	02/ 6/84	381.23	378.37
64	03/ 6/84	381.23	378.37
65	04/ 6/84	381.77	378.37
66	05/ 6/84	381.77	380.02
67	06/ 6/84	382.2	380.02
68	07/ 6/84	382.35	380.02
69	08/ 6/84	382.62	380.02
70	09/ 6/84	383.01	380.02
71	10/ 6/84	383.4	380.02
72	11/ 6/84	383.4	380.81
73	12/ 6/84	383.54	380.81
74	13/ 6/84	383.54	380.81
75	14/ 6/84	383.66	380.81