ABSTRACT

INSPECTION DEPARTMENT MANPOWER PLANNING USING SIMULATION MODELS

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SUMMARY

This paper presents two points of interest. The first is a relatively straightforward application of a simulation study to help solve a problem of understanding and planning manpower requirements in an Inspection Department. The second is an account of the problems encountered by the managers associated with this Inspection Department in preparing a simulation model with only a minimum of assistance from professional computor programmers.

INTRODUCTION

Two events occurred at Eimac which set the stage for this adventure into simulation studies. One event was an organizational change in which workloads were shifted between various plants which in turn resulted in a new and somewhat unknown level of workload at the Eimac Receiving Inspection Department. The second event was the assignment of a new Inspection Foreman into the Eimac Receiving Department. Thus, a situation existed in which an unknown workload level was faced by a new manager who was basically inexperienced in the operating systems within the Department.

After several weeks of shake-down, the Inspection Foreman noticed that the backlog of jobs increased to a level that appeared alarming, and he approached the Manager of Quality Assurance with requisitions for several additional inspectors so that this increasing backlog of work could be held to a reasonable level.

The Manager of Quality Assurance was under pressure from divisional management to keep operational costs as low as possible, so he was reluctant to acquire additional personnel unless they were absolutely necessary. In discussing the problem with the Foreman, it became clear that neither person had any real information on what the Receiving Inspection workload was, or how the requirements changed under different input levels. It was decided to hold off acquiring any additional inspectors until a quick study could be made of the workload requirements.

The Manager of Quality Assurance had previously attended a one-day Seminar on General Purpose Simulation System (GPSS), and had a copy of the User's Manual available. Both Managers had some limited experience in FORTRAN programming and thus felt very brave at attempting a GPSS model. Since at the time the corporate programming services and operation research services were not available on short term notice, it was decided by the two managers that they would construct the GPSS model by themselves.

GPSS MODEL

A Flow Chart of the Receiving Inspection System was relatively straight-forward to construct, and after several adjustments and modifications a chart as shown in Figure 1 was achieved. This chart shows the basic activities and relationships within the system in a conventional manner.

Next, a GPSS block diagram was constructed to define the Receiving Inspection System in the terminology of the computor program, and after several adjustments and modifications, a model, as shown in Figure 2, was achieved.

In this model, each transaction is a lot of goods, such as raw materials, parts, components, etc., purchased from outside suppliers and forwarded to Receiving Inspection for acceptance. Each lot varies in quantity, complexity inspection time, etc. A unit of time of one-tenth of an hour was chosen to be consistent with labor reporting practices within the company.

The Generate block inputs transactions (lots) into the model at random times in accordance with function FN1. The lot moves to a queue (CLRK) waiting for an Inspection Clerk. The clerk identifies the lot and initiates the necessary paperwork in a time defined by function FN8.

The lot leaves the clerk and one-third of the lots are forwarded to other areas for inspection. The remaining two-thirds of the lots are then separated into lots containing parts, and those that are basic raw materials such as rod, bar, sheet, etc.

The raw material lots enter a queue (MATQ) awaiting a Material Inspector. The inspector performs the required inspection in a time defined by function FN9. Ninety percent of the raw material lots require a laboratory analysis and these lots enter a queue (LAB) awaiting a Laboratory Technician. The technician performs a material analysis in a time defined by function FN6.

The lots composed of parts and components enter a queue (INSP) awaiting a Part Inspector. The inspector checks to see if he has the required drawings and specifications, and if not, obtains them in two-tenths of an hour. The inspector then inspects the lot in a time defined by function FN5, and also spends a time defined by function FN10 talking to expediters, engineers, and preparing certain documents and other paperwork.

The inspected and tested lots that fail to comply with specified requirements must be submitted to a Material Review Board, who completes the review in a time defined by function FN7.

PROBLEMS DEFINING FUNCTIONS

The basic flow diagram of the model was easy to prepare, but difficulties were encountered establishing the proper descriptions of the functions.

The first approach was to question the various persons associated with the actual work and obtain their estimates of the times required to perform the various tasks. It was found that the data thus obtained was very inaccurate and not satisfactory for any meaningful simulation study results.

The second approach was to obtain data by actually measuring the times required to conduct the various tasks. For example, the inspectors were all asked to record the inspection time for each lot on the back of a computor card processed with each lot, the laboratory analysis time was obtained by comparing the log-in and log-out times for each lot at the Materials Laboratory, etc.

With this new data, the model functions were modified and more reasonable results were obtained from the computor runs. However, the simulation studies still produced results not suitably close to the observations of the real life situation.

As a final step, the Receiving Inspection operation was studied using work sampling techniques and it was found that one major and several minor areas needed correction in the model. These changes were made and the final GPSS Program is shown in Figure 3.

SIMULATION STUDY RESULTS

The primary areas of concern in this problem were how did manpower utilization, backlog, and transit time vary with different manpower levels at different input levels of lots to be inspected. Accordingly, a series of computor runs were made with the generate function modified to produce different input rates, and the availability of manpower for the different job skills was varied by changing the storage capacity. A family of curves was obtained for each job classification for different levels of input activity which showed the percent utilization of the work crew, number of lots average back-log, maximum number of lots backlog, percentage of lots with zero delay, transit times, etc. The family of curves for average utilization of the manpower is shown in Figure 4, as an example of the way the program data was utilized.

GENERAL DIFFICULTIES ENCOUNTERED

In addition to the problems encountered in trying to obtain valid data to define the functions the following general problems were experienced.

First, there were the normal problems of debugging a program, and these were certainly compounded by the fact that the two managers preparing the program were not skilled in this area. The specific problems were improper parameter definitions, reversing the dependent and independent variables in the functions, improper uses of the units of time, etc. It took six tries to get the program to run, and another five or six tries before the results were useable.

Second, the original plan was to make a quick study, which was originally conceived of lasting a week or two. The program actually took about three months to get the information required. This was primarily due to the time required to get the valid data for the function definitions, and the fact that the managers were unable to devote sufficient time to the program because of other job demands.

USEFULNESS OF THE PROGRAM

The results of this simulation study effort were very useful, although the value of the study came about in somewhat unexpected ways.

1. The major value was that it was necessary to really learn in detail how the Receiving Inspection Department operated before a useable simulation model could be achieved. Although the actual data obtained from the computor runs was useful, it primarily tended to support and make valid the relationships that became somewhat obvious during the model construction.

2. The model and its definitions serves as a common denominator of understanding between all persons involved in the Receiving Inspection operation. Discussions using the model as a common basis of understanding are much more specific and to the point than when such a clear understanding of an operation is not available.

3. The model does have predictive capabilities, and a high level of confidence can be achieved that we can predict how the department will function at input levels that we have not yet actually experienced.

CONCLUSION

The experience in simulation studies described in this paper was successful and of real value to those concerned. Based upon this experience, the following conclusions can be made.

1. It is highly recommended that the ultimate user of the program data should be intimately involved throughout the entire effort, and not just assign the problem to professional programmers and system people and then sit back and wait for results.

2. The professional programmers and systems people should be used to a greater degree than they were in the specific study described. Whereas the two managers certainly had a high degree of involvement in the program, the efficiency of the overall operation was lowered because they had to spend a fair amount of time learning computor programming techniques.

3. The GPSS language and techniques are relatively easy to understand. This makes it very useful for a person who is unskilled in computor programming to contribute effectively to establishing simulation models.

4. The use of a simulation model tends to reach a point of diminishing returns where the added costs of further refinement and added accuracy do not contribute appreciably to the value of the model to the user.

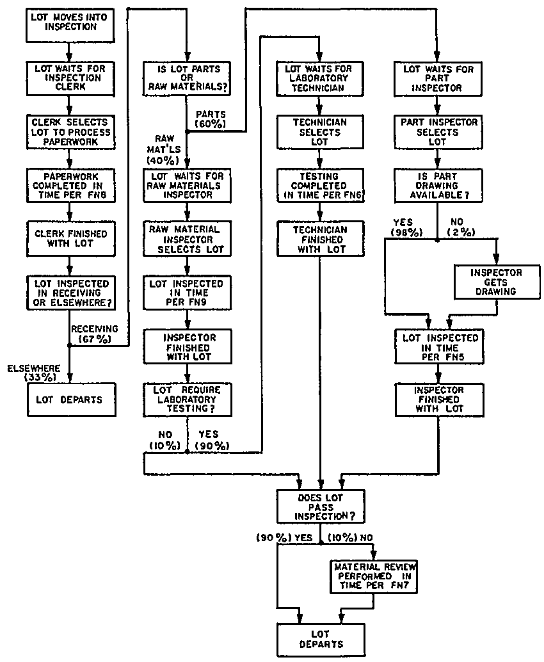

FIGURE 1 - FLOW CHART OF RECEIVING INSPECTION SYSTEM

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*  EIMAC RECEIVING INSPECTION SYSTEM                                  SIMULATION STUDY
*
*  TABLES OF FUNCTIONS
      1  FUNCTION     RN1,D5                       LOT ARRIVAL INTO INSPECTION
0.50     1.0    0.7   2.0    0.8    3.0            0.95   4.0    1.0    5.0
      5  FUNCTION     RN1,D11                      INSPECT LOT TIME
0.1      1.0    0.25  2.0    0.4    5.0            0.65   10.0   0.75   15.0   0.85   20.0
0.9      30.0   0.96  40.0   0.98   50.0           0.99   60.0   1.0    70.0
      6  FUNCTION     RN1,D9                       TIME TO TEST MATERIAL SAMPLE
0.25     10.0   0.5   20.0   0.65   30.0           0.75   40.0   0.85   50.0   0.90   60.0
0.95     70.0   0.98  80.0   1.0    90.0
      7  FUNCTION     RN1,D10                      MATERIAL REVIEW TIME
0.05     10.0   0.2   20.0   0.5    30.0           0.7    40.0   0.85   50.0   0.9    60.0
0.94     70.0   0.96  80.0   0.98   90.0           1.0    100.0
      8  FUNCTION     RN1,D5                       CLERICAL PAPERWORK TIME
0.7      1.0    0.9   2.0    0.95   3.0            0.98   4.0    1.0    5.0
      9  FUNCTION     RN1,D12                      TIME TO INSPECT RAW MATERIAL
0.1      1.0    0.3   2.0    0.45   3.0            0.55   4.0    0.65   5.0    0.75   8.0
0.85     12.0   0.9   16.0   0.93   20.0           0.96   30.0   0.98   50.0   1.0    80.0
     10  FUNCTION     RN1,D8                       INSPECTOR NON-INSPECTION TIME
0.1      1.0    0.3   2.0    0.5    4.0            0.7    8.0    0.85   12.0   0.9    16.0
0.95     20.0   1.0   30.0
*
1              GENERATE   FN1                      LOTS ARRIVE AT RANDOM TIMES
2         INSP QUEUE      ICLKQ
3              MARK       5                        RECORD TIME INTO INSP. DEPT.
4              ENTER      ICLRK                    LOT AWAITING AN INSPECTION CLERK
         ICLRK STORAGE    2                        NUMBER OF INSPECTION CLERKS
5              DEPART     ICLKQ                    CLERK SELECTS LOT
6              ADVANCE    FN8                      CLERK PERFORMS PAPERWORK
7              LEAVE      ICLRK                    CLERK FINISHED
8              TRANSFER   .330,YES,OUT             INSPECT AT RECEIVING INSPECTION OR N
9          YES TRANSFER   .600,RMTL, PARTS         LOT RAW MATERIAL OR PARTS
10        RMTL QUEUE      MATQ
11             ENTER      RMINS                    LOT AWAITING RAW MATERIAL INSPECTOR
         RMINS STORAGE    3                        NUMBER OF RAW MAT'L INSPECTORS
12             DEPART     MATQ                     INSPECTOR SELECTS LOT
13             ADVANCE    FN9                      RAW MATERIAL INSPECT TIME
14             LEAVE      RMINS                    INSPECTION FINISHED
15             TRANSFER   .100,OUT,NON             LABORATORY TESTING NEEDED OR NOT
16         NON TRANSFER   ,TFX
17         OUT QUEUE      TESTQ
18             ENTER      LAB                      SAMPLE SENT TO LAB FOR TESTING
           LAB STORAGE    7                        NUMBER OF TEST TECHNICIANS
19             DEPART     TESTQ                    TECHNICIAN SELECTS SAMPLE
20             ADVANCE    FN6                      SAMPLE TESTED IN TIME PER FN6
21             LEAVE      LAB                      TESTING FINISHED
22             TRANSFER   ,TFX
23       PARTS QUEUE      INSPQ
24             ENTER      PINSP                    LOT AWAITING PART INSPECTOR
         PINSP STORAGE    8                        NUMBER OF PARTS INSPECTORS
25             DEPART     INSPQ                    INSPECTOR SELECTS LOT
26             TRANSFER   .02,JAX,NEIN             IS DRAWING AVAILABLE
27         JAX ADVANCE    FN5                      LOT INSPECTED IN TIME PER FN5
28             ADVANCE    FN10                     INSPECTOR INTERRUPTIONS
29             LEAVE      PINSP                    INSPECTION FINISHED
30             TRANSFER   ,TFX
31        NEIN ADVANCE    2                        INSPECTOR GETS DRAWING
32             ADVANCE    FN5                      LOT INSPECTED IN TIME PER FN5
33             LEAVE      PINSP                    INSPECTION FINISHED
34         TFX TRANSFER   .900,MRB,TAB
35         MRB ADVANCE    FN7                      HOLD MATERIAL REVIEW BOARD PER FN7
36         TAB TABULATE   XTIME                    COUNT TIME IN INSPECTION DEPT.
37         OUT TERMINATE
38             GENERATE   400
39             TERMINATE  1
         XTIME TABLE      MP5,0,80,25              TIME FOR LOT TO FLOW THRU INSP.
               START      1
               RESET
               START      30
               END
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FIGURE 3 - EIMAC RECEIVING INSPECTION GPSS PROGRAM

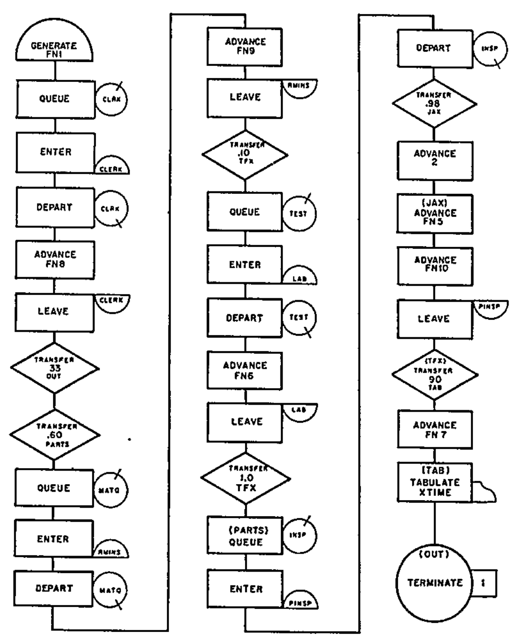

FIGURE 2 — BLOCK DIAGRAM OF RECEIVING INSPECTION SYSTEM

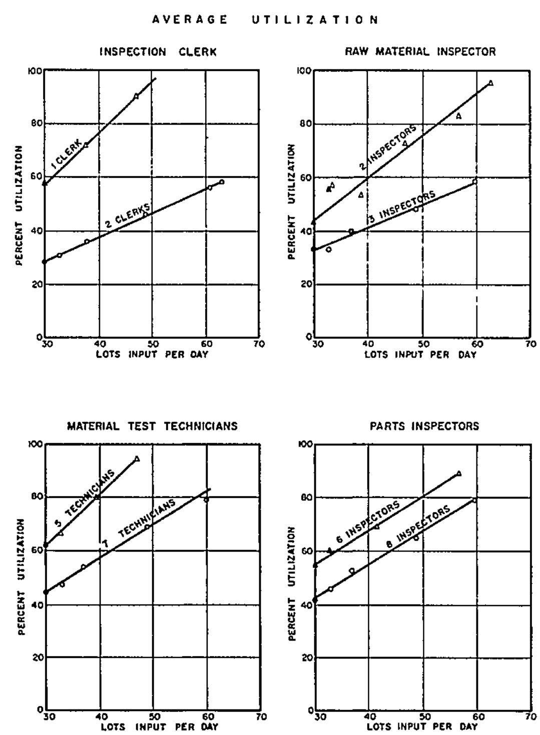

FIGURE 4 - CHARTS SHOWING PERCENT UTILIZATION OF MANPOWER BY CATEGORIES